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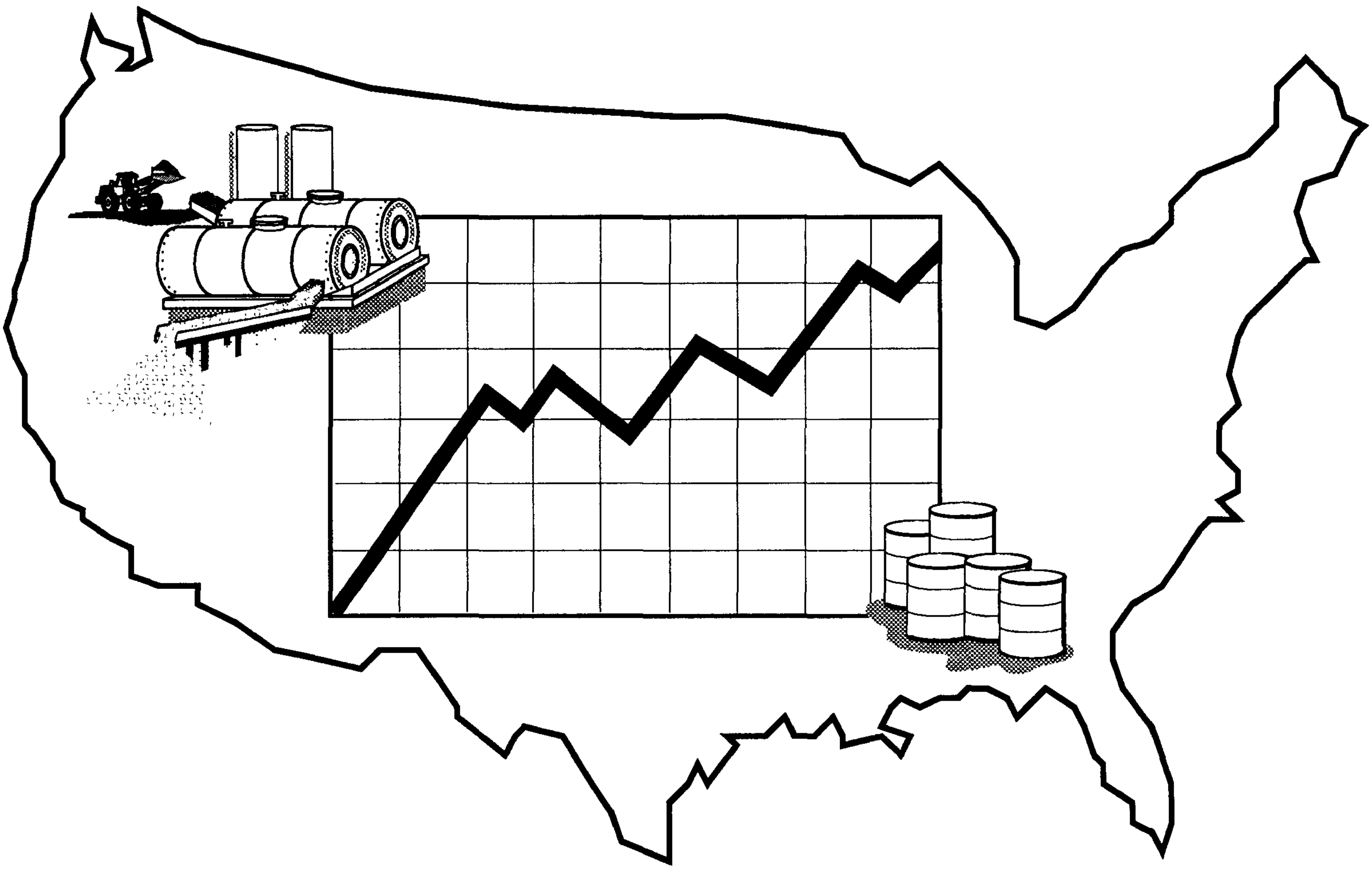
Cleaning Up the Nation's Waste Sites: Markets and Technology Trends



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CLEANING UP THE NATION'S WASTE SITES:

MARKETS AND TECHNOLOGY TRENDS

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, D.C. 20460

NOTICE

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FOREWORD

Over the next 20 to 30 years, federal, state, and local governments and private industry will commit billions of dollars annually to clean up sites contaminated with hazardous waste and petroleum products. This report captures information on the future demand for remediation services for all major cleanup programs in the U.S., including Superfund, Resource Conservation and Recovery Act (RCRA) corrective action, underground storage tanks, state programs, and federal agencies such as the Departments of Defense and Energy. The market information should help innovative technology vendors, developers, and investors direct their research, development, and commercialization efforts towards pertinent waste programs and problems.

The report makes this market information available in one document. Because many cleanup programs are in the early stages of site identification and assessment, the available data provide only a partial picture of site characteristics and technology needs. Thus, the effort to collect and standardize the information on the future remediation requirements proved to be a particular challenge. The most detailed analysis in the report pertains to Superfund sites, for which the available information is the most comprehensive. We hope that as data on the site characteristics of the other programs become available, future studies will permit more detailed characterization of their needs.

Meanwhile, this report provides a compilation of market data that are currently available and descriptions of national cleanup programs. Improved access to data on domestic markets will help direct the development of new technology and strengthen U.S. capabilities in environmental cleanup. As companies acquire field experience in this country, they will be better equipped to compete internationally.

Walter W. Kovalick, Jr.

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Director, Technology Innovation Office

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TABLE OF CONTENTS

EXHIBITS

CHAPTER 1
INTRODUCTION AND FINDINGS

1.1 Purpose

Over the next 20 to 30 years, federal, state, and local governments and private industry will commit billions of dollars annually to clean up sites contaminated with hazardous waste and petroleum products. This commitment will result in an increase in the use of all types of site remediation services. While existing technologies to remediate contaminated sites have been successful, the investment in site cleanup offers new opportunities for the development of less expensive and more effective solutions.

The purpose of this report is to provide innovative technology vendors, developers, and investors with information on the future demand for remediation services. This information will enable them to better direct their research and development efforts toward the nation's hazardous waste problems. The report addresses site characteristics, market size, and other demand factors of the major waste site cleanup programs in the U.S. Although this report is designed to serve those who are developing and commercializing new cleanup technologies, it will be useful to any company providing site remediation services.

1.2 Scope

In this study, the market includes site cleanup activities for which contracts have not been issued. These activities represent business opportunities for vendors of remediation services. This market includes many sites currently undergoing site investigations and feasibility studies. Because these investigations are not yet complete, the full extent of the cleanup work needed can only be estimated. Most data in the report are current through fiscal year 1991, although fiscal year 1992 data also are used when possible.

The national cleanup market has been divided into eight segments:

- National Priorities List (Superfund)
- Resource Conservation and Recovery Act (RCRA) corrective action
- Underground storage tanks (UST)
- Department of Defense (DOD)
- Department of Energy (DOE)
- Other federal agencies
- States
- Private parties

For each market segment, five areas are discussed: (1) the structure, operation, and regulatory requirements of the program; (2) the economic and political factors that may change the size or characteristics of the market segment; (3) the quantitative measures of the market in terms of the number of sites, occurrence of contaminants, and extent of remediation work needed; (4) estimates of remediation costs; and (5) procurement and technology issues.

Most of the data in the report are from published sources or central databases. The collection of information at the state or individual facility level is impractical, because there are no national repositories of these data. Also, the status, organization, and data collection practices differ widely among the eight market segments. Information on the more established programs, such as Superfund, is generally more complete than that available for the other programs. Based on historical trends and site characteristics in the Superfund program, the report provides general observations concerning possible future technology applications.

1.3 Site Remediation Technologies

Prior to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Resource Conservation and Recovery Act of 1976 (RCRA), most hazardous waste was disposed in landfills. These laws, as amended, require remedies that treat, rather than dispose of, waste to the "maximum extent practicable." Consequently, the U.S. Environmental Protection Agency (EPA) defines alternative treatment technologies as "alternatives" to land disposal. The most frequently used alternative technologies are incineration and solidification/stabilization. Available information on these two technologies is sufficient to support their routine use.

EPA defines "innovative treatment technologies" as those that lack the cost and performance data necessary to support their routine use. The most common innovative technologies are soil vapor extraction (SVE), thermal desorption, bioremediation, and soil washing. In general, a treatment technology is considered innovative if it has had only limited full-scale application. Often, the first-time application of an existing technology or process to new waste types is what makes it innovative.

This report provides information that is useful for approximating the market for a particular remediation technology. In practice, it is impossible to definitively determine the size of the market for a cleanup technology until the full extent of the contamination at sites is known, and until it is clear which applications are best for each technology. This report summarizes past technology applications, but it does not assess the specific merits of each technology, nor the capabilities of specific companies that provide remediation services.

1.4 Overview of Findings

The demand for remediation technologies is large and growing. Each of the eight major cleanup markets has a substantial amount of work left to accomplish. Some programs expect to take 30 years to complete the remediation of known sites. Most of these programs will cost tens of billions of dollars, while the DOE cleanup program will cost hundreds of billions.

Many contamination problems are similar among the major remediation programs. Nevertheless, some programs have wastes that are unique to a particular industrial practice. Contaminants common to most programs include solvents, petroleum products, and metals. Examples of specialized wastes include munitions and explosives at DOD sites and radioactive material at DOE installations. Contaminated soil and ground water are the most prevalent problems, but large quantities of other contaminated material, such as sediments, landfill waste, and slag, also are present at many sites.

Although it is difficult to forecast the usage of specific technologies, historical trends in the Superfund program provide some insight. Increasingly, Superfund remedies call for the treatment of waste on-site and treatment of soil without excavation. Established technologies, primarily incineration and solidification/stabilization, will continue to play an important role in treatment of waste both on-site and off-site. However, the use of innovative technologies is growing. Soil vapor extraction has been the most widely used innovative technology, and enhancements to this process are expected to lead to increases in its effectiveness and range of applications. The use of on-site preprocessing technologies, such as thermal desorption, also is growing. While the number of Superfund applications of current bioremediation techniques has not grown over the past two years, new developments may lead to increased usage at Superfund sites. This technology may have broader application in other programs, particularly UST site cleanups. The most common contaminants at NPL (National Priorities List) sites remaining to be cleaned up are chlorinated VOCs and various metals. The greatest needs for new technologies in the Superfund program appear to be for metals in soil and the treatment of ground water in place, without pumping to the surface.

Regardless of the similarities or differences in contamination problems among the programs, marketing approaches for technology development and remediation services must be tailored to accommodate differences in program structure, requirements, and site characteristics. Federal agencies—especially DOE, DOD, and EPA—are responsible for many remedial actions, and each has a somewhat different program structure. Private parties also are directly responsible, with federal or state oversight, for many cleanups, including USTs, RCRA corrective actions, state program sites, and most Superfund remedial actions. Research and development efforts under federal and some state programs also may affect marketing strategy.

The findings for each of the specific market segments are presented in the following sections.

1.5 National Priorities List (Superfund) Sites

Superfund is a federal program, administered by EPA under CERCLA (as amended) to clean up the nation's worst abandoned hazardous waste sites. CERCLA created a trust fund for site identification and remediation, and important enforcement authorities. Over its 12-year history, the primary responsibility for NPL site cleanups has shifted from EPA to private industry ("responsible parties"). Currently, over half of all investigations and almost 75% of all cleanups are being implemented by responsible parties, with EPA or state oversight. For the remaining sites, EPA or the state has primary responsibility.

Superfund has been progressing from evaluation of sites into design and cleanup. As of September 1992, EPA had conducted preliminary assessments of over 95% of the 36,814 potentially hazardous sites listed in EPA's database. Of these, 1,235 sites are currently listed on the NPL. In the past two years, the number of sites entering remedial action has grown steadily. The 123 remedial actions started during fiscal year 1992 was a 20% increase over 1991, and a 60% increase over 1990. By the end of 1992, construction activity had been completed or deletions from the NPL had occurred for 149 sites; and EPA had conducted 2,155 emergency removal actions.

EPA will incur costs of $16.5 billion to clean up sites currently listed on the NPL. EPA funding for fiscal year 1993 is $1.6 billion. However, most sites will be remediated by potentially responsible parties, and estimates of their costs are not available. The average cost for EPA to clean up a site is $27 million for all remedial activities, including investigations, and $13.2 million for remedial action alone.

EPA has an active research and demonstration program for most types of innovative cleanup technologies. EPA's primary mechanism for testing new technologies is the Superfund Innovative Technology Evaluation (SITE) program, which has a fiscal year 1993 budget of $14 million. The program is evaluating almost 150 technologies.

1.5.1 Technology Trends

Superfund now emphasizes the use of permanent remedies and the development and demonstration of new remediation technologies. This emphasis has lead to the following trends in the types of technologies selected and used for NPL site cleanups:

- More than 30% of sites with Records of Decision (RODs) signed in 1991 are expected to use at least one innovative technology, and some sites will use more than one.

- The selection of innovative technologies for Superfund cleanup has been increasing. In 1991, for the first time, innovative treatment technologies accounted for more than half of the treatment technologies selected for controlling the source of the waste.

- SVE accounts for much of the growth in the selection and use of innovative treatment technologies at Superfund sites, constituting 40% of these applications. Bioremediation makes up 21% of all innovative technologies selected, followed by thermal desorption, soil washing, and *in situ* flushing. Dechlorination, *in situ* vitrification, solvent extraction, air sparging, and *in situ* steam recovery of oily wastes comprise the remainder.

- The selection of incineration and solidification/stabilization, which are considered established technologies, is slowly decreasing, but these technologies continue to play a large role in Superfund cleanups. They account for 47% of all treatment technologies selected in fiscal year 1991. On-site incineration was selected for only four sites that year, whereas off-site incineration (at existing permitted facilities) was selected for 26 sites.

- At least 35 Superfund sites use multiple innovative treatment technologies in "treatment trains" of two or more technologies in sequence.

- Most ground water remediation involves extraction processes, rather than methods to treat aquifers in place.

About 10% of the innovative technology projects have been completed. Most cleanups involving innovative technologies are in the design stage, and will be implemented in the next three to four years. These cleanups represent a "short-term" market for remediation services.

1.5.2 NPL Site Characteristics

Superfund sites that have not begun remedial action make up a relatively well-defined market for remedial technologies. Remedies have not been selected for as many as 750 of the sites that currently are listed on the NPL. Remedial actions for these sites will begin in three to eight years, and are referred to as "intermediate-term" demand. Although further study is needed to determine which wastes actually require remediation, the data available on these sites can be used to indicate the types and extent of treatment technology applications needed in the future:

- Volatile organic compounds (VOCs) are the most common contaminant groups, followed by metals and semi-volatile organic compounds (SVOCs). Most sites contain only one of these, but a significant number contain two groups (but not necessarily in the same contaminated material).

- Chlorinated VOCs are by far the most common organic contaminant, followed by nonchlorinated VOCs, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and phenols.

- The most common metal is lead, followed by chromium, arsenic, and cadmium.

- Most sites require both ground water and soil remediation. EPA estimates that 80% of future sites will need remediation of contaminated ground water, 74% for soil, 15% for sediments, and 10% for sludge.

- About 26 million cubic yards of soil, sludge, and sediment need to be cleaned up. This estimate is probably conservative because sites are usually more complex than site assessments first indicate. The material to be cleaned up includes: 20.5 million cubic yards of waste containing metals alone or in combination with other contaminants; 13.9 million cubic yards of VOCs alone or in combination with other contaminants; and 7.25 million cubic yards of SVOCs. The largest quantities of contaminated material are found at sites used to manufacture primary metal products and metal plating sites—14 million and 8.9 million cubic yards, respectively.

The long-term demand includes 400 to 800 sites that EPA estimates will be listed on the NPL between 1993 and 2000. Remedial action for these sites will begin in 8 to 16 years. The characteristics of these future sites may be different from sites already listed, because EPA will evaluate them for listing under a revised system that places increased emphasis on contaminated soil and sediment.

1.5.3 Future Technology Use at NPL Sites

Based on contaminant occurrence and historical technology trends, general observations can be made about the potential Superfund market for specific technologies. These observations do not consider several other important factors in remedy selection, such as cleanup standards, competing technologies, other site characteristics, and public acceptance.

- The use of SVE technologies for all types of VOCs is expected to continue at current levels, and may even increase. SVE has become the technology of choice for both chlorinated and nonchlorinated VOCs in soil and VOCs are the most common type of contaminant at intermediate-demand sites. New techniques for increasing soil permeability and contaminant volatility may lead to further expansion of SVE applications.

- Thermal desorption for the treatment of VOCs and PCBs may increase. Thermal desorption can be used for VOCs when site conditions are not amenable for SVE. In addition, thermal desorption is frequently selected for PCBs, which also occur frequently at intermediate-demand sites.

- Although the selection of bioremediation has been constant over the past several years, new developments may lead to some increase in its use for Superfund sites. These advances include the results of extensive research into bioremediation, and the trend towards increased use of air-based methods to aerate soil and ground water in place. However, one factor that will ultimately limit the number of sites amenable to bioremediation is the lack of biodegradable compounds, such as PAHs, at Superfund sites. In the long term (beyond eight years), additional listings of wood preserving sites on the National Priorities List may increase bioremediation opportunities.

- More alternatives to incineration are needed for the treatment of SVOCs. Incineration probably is the most commonly used technology for treating SVOCs; innovative technologies have been selected far less frequently.

- Treatment of metals in soil represents a potentially large, but untapped, market for innovative treatment. Solidification/stabilization is currently the treatment of choice for metals. There is a need for increased use of new separation technologies (such as soil washing) that reduce the quantity of waste requiring solidification/stabilization, or allow the recycling of valuable metals.

- Techniques to treat contaminated ground water in place are in great demand. Pump-and-treat technologies often cannot achieve desired cleanup goals. New *in situ* ground water treatment technologies are needed to address residual contamination in the aquifer.

- Based on current trends, at least 30% of the Superfund sites will implement innovative technologies for source control. This is a conservative estimate, and the rate of innovative technology use should grow as more cost and performance data become available. Incineration and solidification/stabilization may be used more for final treatment after innovative techniques have been used to separate and recover contaminants.

1.6 RCRA Corrective Action Sites

Approximately 5,100 hazardous waste treatment, storage, and disposal facilities (TSDFs) are potentially subject to corrective action under the Resource Conservation and Recovery Act (RCRA). Approximately 80,000 pre-existing "solid waste management units" are located at TSDFs. Most RCRA facilities are ongoing operations, although many operators are in the process of closing or have closed their TSD units. The site owners or operators are responsible for the necessary corrective action, with oversight by EPA or a state. Major considerations for the RCRA corrective action market are given below:

- EPA estimates that the total cost of corrective action for soil and ground water will be between $7.4 billion and $41.8 billion. A recent EPA analysis suggested that the present value cost would be about $18.7 billion under the proposed regulations, at a weighted average cost of $7.2 million per facility. However, this value is likely to change when final regulations are issued.

- Between 1,500 and 3,500 of the regulated TSDFs will require corrective action.

- The pace of cleanup activity has increased in the past year as a result of an initiative to stabilize waste and prevent further spreading. As of the end of fiscal year 1992, corrective measures were underway or completed at 247 facilities, a substantial increase over the 136 of two years ago. About 3,500 facilities have completed a RCRA facility assessment, the first step in the cleanup process, and 614 are undergoing a RCRA facility investigation.

- A wide variety of wastes, many of which are similar to those found at Superfund sites, will require corrective action. Some of the most prevalent wastes include corrosive and ignitable wastes, heavy metals, organic solvents, electroplating waste, and waste oil.

- Based on a small sample of planned or implemented corrective actions, about half use off-site disposal remedies and half use innovative treatment. Off-site remedies include landfilling or off-site incineration. Of the innovative technologies, about one-third each are SVE, *in situ* bioremediation, and above-ground treatment, primarily bioremediation. The sample may have missed the use of solidification/stabilization, which is commonly selected for Superfund sites.

1.7 Underground Storage Tank Sites

Underground storage tanks (USTs) containing petroleum products or hazardous chemicals are also regulated under RCRA. Tank owners are responsible for remediation under state UST programs. Major factors concerning UST site remediation include the following:

- Approximately 295,000 UST sites, containing at least 56 million cubic yards of soil and debris, require cleanup. There is an average of almost three USTs per site. This estimate includes

119,000 confirmed releases that have not yet been cleaned up plus 176,000 projected releases. Previous studies indicate that the cost to clean up one site ranges from $2,000 to over $400,000. At an average cost of $100,000, the potential UST market could reach $30 billion.

- Both the pace of UST cleanups and the backlog of cleanup projects have grown. The almost 29,000 UST cleanups completed in fiscal year 1992 was almost triple the 10,400 cleanups completed in fiscal year 1991. Nevertheless, the gap between confirmed releases and cleanups completed has grown from 100,000 at the end of 1991 to 129,000 by the end of 1992.

- Approximately 91% of USTs contain petroleum products and 2% contain hazardous materials. For USTs containing petroleum products, gasoline accounts for 66%, and diesel fuel for 21%.

- Limited data indicates that about 40% of UST cleanups use innovative technology. Landfilling comprises over half of the technologies selected to treat petroleum contaminated soils, followed by *in situ* treatment, thermal treatment, and bioremediation. Soil vapor extraction, *in situ* bioremediation, and thermal desorption are the most frequently cited innovative technologies.

1.8 Department of Defense Sites

DOD is responsible for the cleanup of facilities contaminated as a result of training, industrial, or research activities. As of September 1991, DOD had identified 17,660 potentially contaminated sites (located at 1,877 DOD installations) and 6,786 formerly used defense sites (FUDs). Of these, about 7,000 will require cleanup. Cleanup policy is determined centrally under the Defense Environmental Restoration Program (DERP), but each service is responsible for its own installations.

DOD estimates that almost all sites have been identified and that cleanup of the sites will be completed by 2011, given adequate funding. Design and construction work will increase through 1998, then moderate until all cleanup is completed. Other key findings are presented below:

- The total cleanup costs will be $25 billion in 1991 dollars, of which $14 billion will be for remedial action. Funding authorization for DOD environmental restoration programs for fiscal year 1992 was $1.4 billion.

- The most common contaminants at DOD sites are similar to those at non-defense industrial facilities: petroleum products, solvents, metals, pesticides, and paints. Some sites also contain more unusual wastes, such as unexploded ordnance or low-level radioactive materials.

- DOD has estimated the typical quantity of contaminated soil for nine of its 20 standard site categories. Typical values range from 500 to 9,500 cubic yards of contaminated soil per site. Among the nine site categories, the largest national estimates of soil quantities are for: disposal pit/dry wells (2.2 million cubic yards), storage areas (2.1 million cubic yards), underground storage tanks (1.6 million cubic yards), and fire/crash training areas (1.2 million cubic yards).

- Examples of innovative treatment technologies used at DOD sites include bioremediation, SVE, and soil washing. DOD is conducting research and demonstrations on many technologies, including bench and field testing of bioventing at almost 140 Air Force sites.

1.9 Department of Energy Sites

Under its Environmental Restoration Program, DOE is responsible for cleaning up 110 major installations and other locations in 33 states and Puerto Rico. DOE estimates that remediation may be required at about 4,000 individual contaminated areas or sites covering more than 26,000 acres at these DOE installations and non-DOE sites. The number of identified sites has been growing as assessment and characterization activities continue. Most sites have been used for nuclear weapons research, development, and production for the past 40 years. DOE installations tend to be much larger than most DOD and other non-DOE Superfund sites. Twenty-three DOE sites on 16 installations and other locations are listed on the NPL. Many installations contain more than one area of contamination. Each area may require different types of remedies.

DOE is committed to cleaning up contamination and bringing all of its installations into environmental compliance by the year 2019. Sites containing VOCs are a high priority.

Other key findings concerning DOE's Environmental Restoration program include the following:

- Funding planned for all DOE cleanup programs for 1994 through 1998 is $12.3 billion. DOE estimates that the total cost of cleaning up DOE facilities will be in the hundreds of billions of dollars.

- Most of the DOE cleanup effort is occurring at 64 DOE installations and other locations managed under the Remedial Actions Program. This includes contaminated buildings at more than 20 sites and about 1.6 million cubic yards of soil that still need to be remediated under the Formerly Utilized Sites Remedial Action Program (FUSRAP). These sites contain residual radioactive material from the early years of the atomic energy program.

- Some contaminants at DOE installations are unique to nuclear production, while others are similar to those generated in a variety of industrial processes. Mixed waste, containing radioactive and hazardous constituents, is a problem at many installations and sites. Based on estimates for a small number of installations, the quantity of contaminated material at individual sites in the Remedial Actions Program can range from 200 to 3.3 million cubic yards.

- In addition to the Environmental Restoration program, Decontamination and Decommissioning (D&D) involves about 500 facilities slated for cleanup by 2019, and as many as 500 additional facilities. This program manages government-owned retired facilities (reactors, laboratories, buildings, storage tanks) used for early nuclear energy research and defense programs.

- Although information on technologies being used at DOE installations is limited, applications known to EPA include: SVE, air sparging, and soil washing. DOE also conducts research and development, primarily in the form of demonstrations of technologies such as *in situ* bioremediation, air stripping, vitrification, electrokinetics, soil washing, solvent extraction, solar detoxification, and above-ground biological treatment.

1.10 Civilian Federal Agency Sites

Other federal agencies, such as the Departments of Agriculture and Interior, are responsible for cleaning up waste sites on property owned or formerly owned by the agencies. As of 1990, 16 agencies identified almost 350 sites in need of remediation. Sites vary from illegal drug operations to landfills and abandoned mines. To address the cleanup of these sites, federal agencies requested a total of over $1 billion for fiscal years 1991-1995. These funds include both administration and remediation costs. Most of these sites are still being assessed, and have not yet progressed to the site remediation stage.

1.11 State Program Sites

States are responsible for assessing and cleaning up sites not being addressed by the federal Superfund nor the UST and RCRA corrective action programs. Many states have created cleanup programs patterned after the federal Superfund program. As of the end of 1991, the balance of available funds in state Superfunds was over $2.2 billion. Three states—New York, New Jersey, and Michigan—account for about 80% of this figure. EPA estimates that over 19,000 state sites require additional evaluation or action beyond a preliminary assessment. Waste at these sites are typical of industrial facilities and include organic chemicals, metals, and solvents.

1.12 Private Party Sites

In addition to sites remediated under state and federal programs, an unknown number of sites are being remediated independently by the private sector. These cleanups result from efforts of companies to limit their potential future liabilities, or from new requirements for environmental evaluations as a prerequisite for real estate transactions. Because these cleanups are not conducted under a specific federal or state cleanup program, no information is available on the number of sites or the amount of remediation work that may be needed. One estimate put the 1991 remediation market for private industry at about $1 billion.

1.13 Using This Document

The information in this document is organized into the following Chapters:

- Chapter 2 describes the current uses and trends in the use of remedial technologies at CERCLA NPL sites.
- Chapter 3 describes the demand for remedial services at NPL sites over the intermediate and long terms. This market segment includes sites for which RODs have not been signed, as well as sites to be listed on the NPL in the future.
- Chapter 4 addresses the demand for remediation services at sites subject to the corrective action provisions of RCRA.
- Chapter 5 reviews the remediation services needed for sites subject to the UST requirements of RCRA.
- Chapter 6 characterizes the DOD Environmental Restoration Program, and the DOD sites that need cleanup.
- Chapter 7 provides an overview of the Department of Energy Environmental Restoration Program, and the DOE sites that need cleanup.
- Chapter 8 summarizes the cleanup needs for three categories of sites: (a) civilian agency sites (federal agency sites other than DOD and DOE); (b) state program sites (state-managed sites that do not qualify for Superfund remedial action and other sites reported to states); and (c) private party sites (sites on private property independently cleaned up by private parties).

References cited in the document are provided at the end of each chapter.

Appendix A contains additional detail on the various market segments; Appendix B is a list of federal agency resources, EPA regional offices, and state solid and hazardous waste offices; Appendix C contains a bibliography of all sources used in the development of this report; and Appendix D contains definitions of terms and acronyms. The acronyms are located on the last two pages of the document.

CHAPTER 2
TRENDS IN THE USE OF REMEDIAL TECHNOLOGIES AT NATIONAL PRIORITIES LIST SITES

The selection of innovative treatment technologies for contaminated waste sites has increased substantially in recent years. These technologies are improving the efficiency and effectiveness of efforts to clean up the country's contaminated sites. An examination of historical trends can be useful in predicting how often these innovative technologies may be selected in the future and how quickly new technologies are integrated into the remediation market.

Because Superfund has been operating the longest and is the most thoroughly documented of the nation's cleanup programs, data on past Superfund decisions provide a basis for analyzing innovative technology trends. This chapter describes the historical trends in the selection of technologies at Superfund sites, the status of their implementation, and the types and quantities of wastes being addressed. These trends also reflect the current status of these technologies; ongoing technology development presumably will alter future technology use.

2.1 The CERCLA Program

The Superfund program is the federal program to clean up releases of hazardous substances at abandoned or uncontrolled hazardous waste sites. Superfund is administered by EPA under authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). In addition to establishing enforcement authorities, CERCLA created a trust fund to be used for site identification and clean up. The Superfund Amendments and Reauthorization Act of 1986 (SARA) made three important changes to the Superfund program that are of particular importance to technology vendors: (1) it stressed the importance of permanent remedies; (2) it allowed the use of new, unproven treatment technologies; and (3) it expanded research and demonstration activities to promote the development of innovative treatment technologies.

2.1.1 The National Contingency Plan

The procedures for implementing the provisions of CERCLA are spelled out in the National Oil and Hazardous Substances Pollution Contingency Plan, commonly referred to as the National Contingency Plan (NCP). This plan outlines the steps that EPA and other federal agencies must follow in responding to releases of hazardous substances or oil into the environment. The national goals described in the NCP are to select remedies that are protective of human health and the environment, maintain protection over time, and minimize untreated waste. The NCP specifies several approaches to achieve these goals:

- Use treatment for principal threats wherever practical;
- Combine treatment with containment, as necessary; and
- Consider innovative treatment technologies to the maximum extent practicable.

2.1.2 The Superfund Process

The traditional process established by the NCP is depicted in Exhibit 2-1. If more than one cleanup action is needed at a site, certain steps in this process are repeated for each action. The process begins with discovery of a potential hazardous waste site, and includes the following general steps:

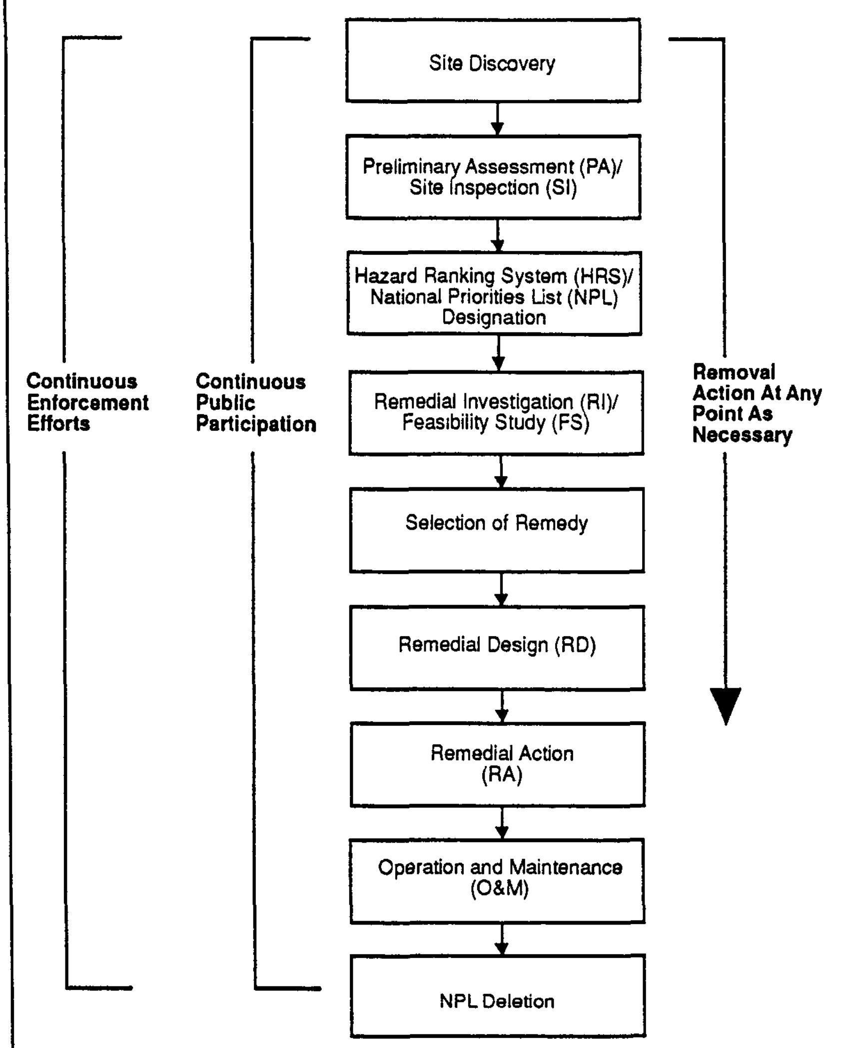
1) A "preliminary assessment" (PA) is conducted to determine the existence of potential threats to human health or the environment that require a "removal action" or further study. If the PA indicates an emergency requiring immediate or short-term action to reduce the risk to the public, a removal action is conducted to stabilize or clean up the site.

2) If a hazard remains after a removal action is performed, a "site inspection" (SI), is conducted to determine whether a site warrants scoring

under the Hazard Ranking System (HRS). EPA uses the HRS to score sites based on the potential effects from contamination on human health and the environment. Sites with an HRS score of 28.5 or higher are proposed for the National Priorities List (NPL).

If the contamination problem is serious enough, the site is included on the NPL, which is EPA's national list of sites with the worst contamination problems. Inclusion on the NPL means that the cleanup of the site can be accomplished with Superfund Trust Fund resources.

Exhibit 2-1: Historical Superfund Process Flowchart



Note: The EPA currently is revising this process under the Superfund Accelerated Cleanup Model.

3) If placed on the NPL, an in-depth planning and investigation phase begins, during which the extent of contamination and site risks are determined and treatment alternatives are evaluated. This phase is known as the "remedial investigation/feasibility study" (RI/FS). EPA requires the results of the RI/FS, including the rationale for selecting a remedy, to be documented in a "Record of Decision" (ROD). Some sites require a series of RI/FSs and RODs to address different "operable units," which are portions of a site or pathways of exposure (*e.g.*, air, water) that require separate cleanup actions.

RODs provide useful information for technology vendors interested in gaining access to the hazardous waste cleanup market. First, RODs specify the technology type determined to be the appropriate remedy for a site. Second, technology vendors can use RODs to determine why EPA selected or rejected a specific remedy. EPA must consider: overall protectiveness; compliance with other environmental laws and regulations; long-term effectiveness and permanence; short-term effectiveness; implementability; cost; and reduction of toxicity, mobility, or volume of wastes. State and community acceptance also are considered.

4) Following the ROD, detailed engineering specifications for the selected cleanup alternatives are developed. This phase is called "remedial design" (RD). The designs are used

to solicit competitive bids to perform the "remedial action" (RA). Remedial action is the phase of the process when waste is actually treated, disposed, or contained.

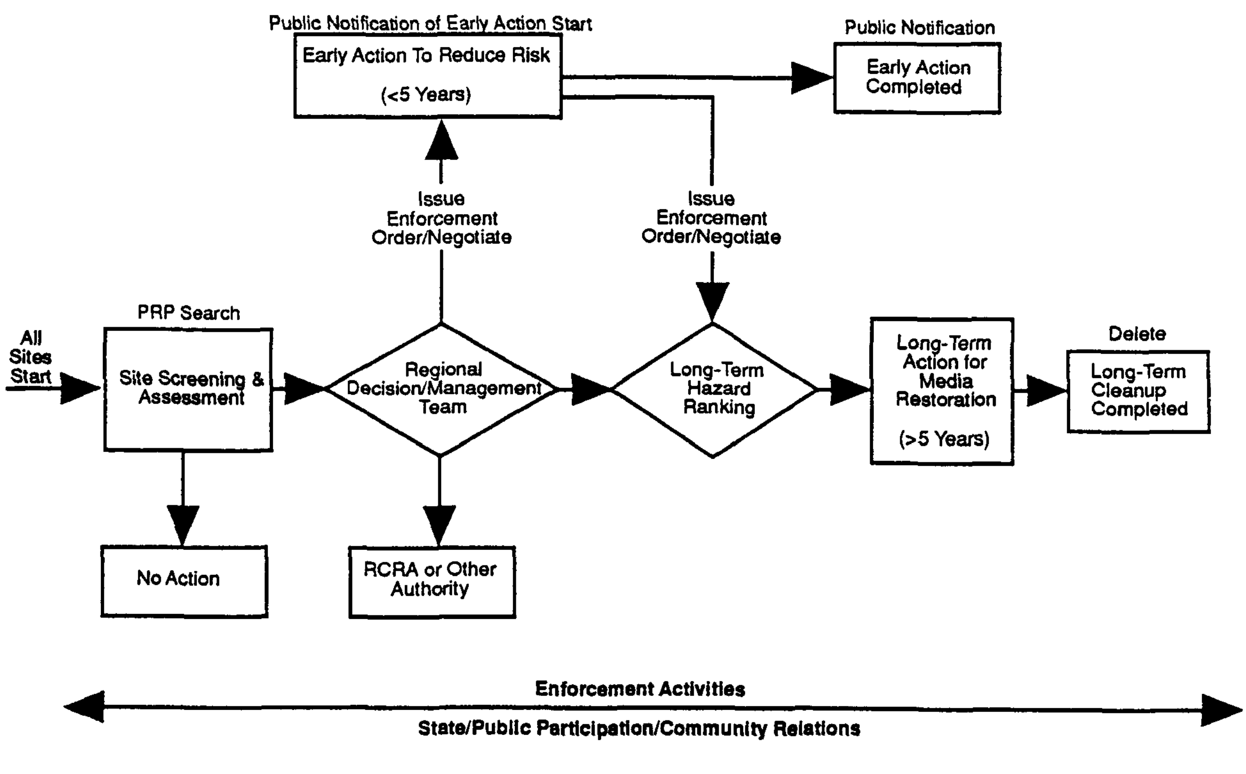
If necessary, "operation and maintenance" (O&M) begins at the conclusion of the remedial action. This phase can include such actions as ground water monitoring and periodic site inspections to ensure continued effectiveness of the remedial actions. The final step in the process is to delete the site from the NPL. This step is initiated when all necessary response under CERCLA is completed.

At any point of this process, an emergency requiring a removal action can occur at a site. In addition, community relations activities take place throughout the process to ensure the involvement of all interested parties in the decision-making process. Also, enforcement actions that compel those responsible for the site contamination to clean up the site, occur throughout the cleanup process to ensure optimal use of Trust Fund resources.

EPA is now taking steps to streamline the process under the Superfund Accelerated Cleanup Model (SACM). The purpose of SACM is to make hazardous waste cleanups more timely and efficient by integrating Superfund's administrative components. The new process is illustrated in Exhibit 2-2. Under SACM, EPA will adopt a continuous process for assessing site-specific conditions and the need for action. Risks will be reduced quickly through early action (removal or remedial). SACM will operate within the existing statutory and regulatory structure. Superfund priorities will remain the same: deal with the worst problems first; aggressively pursue enforcement; and involve the public at every stage of the work.

Because EPA is responsible for implementing the Superfund program, it is responsible for determining the best way to clean up each site. Other federal

Exhibit 2-2: Superfund Accelerated Cleanup Model (SACM)



Source: U.S. EPA, Office of Emergency and Remedial Response, October 1992.

agencies such as the Department of Defense (DOD) and Department of Energy (DOE) are responsible for cleaning up NPL sites at their facilities in accordance with the requirements of the NCP and with EPA concurrence and oversight. Under the Superfund program, states also may take the lead to determine the best remedial alternatives and contract for the design and remediation of a site.

2.1.3 Program Status

Much of the past effort under Superfund has been to rank sites, conduct detailed remedial investigations, select remedies, and address immediate threats. As of September 30, 1992, (the end of fiscal year 1992) EPA has conducted preliminary assessments at over 95% of the 36,814 potentially hazardous sites listed on the Comprehensive Emergency Response and Compensation Information System (CERCLIS), EPA's Superfund tracking system. Of these, EPA has listed 1,275 sites on the NPL, of which 40 have been deleted (most of these because cleanup has been completed), resulting in a current total of 1,235.[a] As more contaminated sites are studied and ranked, they will be added to the NPL.

Between fiscal years 1982 and 1991, EPA made cleanup decisions in 967 RODs for 712 NPL sites. In the last two years, the number of sites where remedial actions have begun has risen steadily. The 123 remedial actions that started in fiscal year 1992 represents a 20% increase over 1991, and 60% over 1990. At the end of fiscal year 1992, construction activity was completed, or deletion from the NPL had occurred, at 149 NPL sites. In addition, EPA has conducted 2,155 removal actions.

2.2 History of Technology Use in Superfund

Since Superfund was established, the approach to cleaning up contaminated sites has evolved from emphasizing containment of waste to promoting waste treatment. Prior to 1986, the most common methods for remediating hazardous waste were to excavate the contaminated material and dispose of it in an off-site landfill, or to contain the waste on-site by means of caps or slurry walls. Because SARA provides a clear preference for the use of permanent remedies, known as "alternative treatment technologies," for the cleanup of Superfund sites, more remedies now include treatment.

Since 1982, over 60% of the RODs that address the source of contamination (*e.g.*, contaminated soil, sludge, sediment) include the treatment of some portion of the waste at the sites. As Exhibit 2-3 illustrates, in each of the past four years (fiscal years 1988-91), more than 70% of the source control RODs specified some treatment to reduce the toxicity, mobility, or volume of a waste. Containment or land disposal also may be prescribed at these sites.

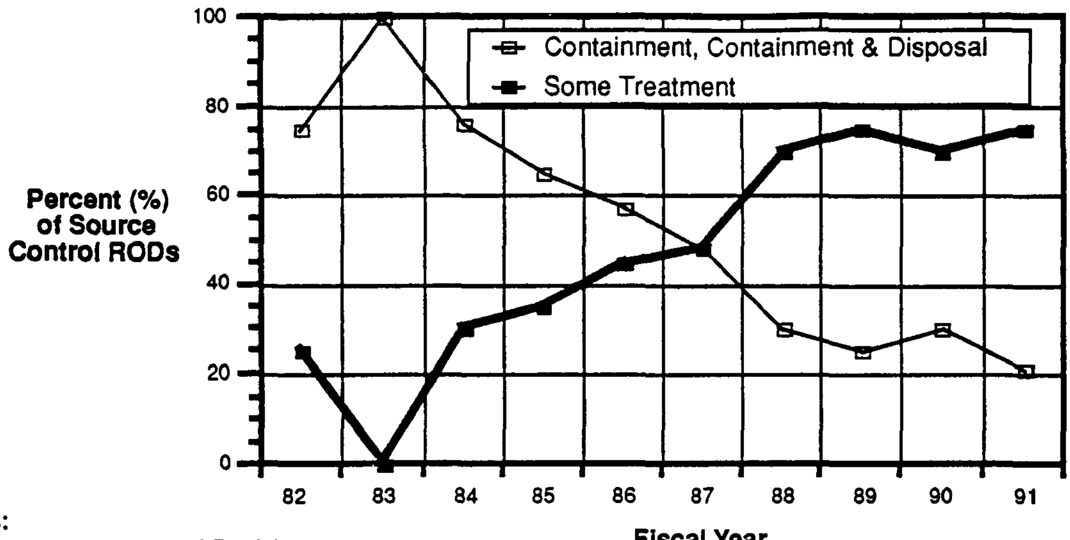
2.3 Innovative and Established Technologies for Treatment

In this report, technologies to treat ground water above-ground, incineration, and solidification/ stabilization are considered to be established remediation technologies. In most cases, available data on the performance and cost of these technologies are adequate to support their regular use for site cleanup. Many new and important developments are being adopted in these technologies, and the EPA's Superfund Innovative Technology Evaluation (SITE) program is evaluating some of these adaptations.[2]

Incineration is the most frequently selected of any technology for treating soil, sludge, and sediment in Superfund and was the first technology available for treating organic contaminants in these matrices. The major advantage of incineration is it is able to achieve stringent cleanup standards for highly-concentrated mixtures of organic contaminants. Exhibit 2-4 presents the frequency of use of established and innovative treatment technologies in the Superfund program. On-site and off-site incineration account for 30% of all treatment processes selected through fiscal year 1992. Off-site incineration is more applicable to smaller quantities (typically less than 5,000 cubic yards) of highly contaminated material and for residuals of pretreatment technologies that separate and

[a] Subsequent to this analysis, these totals have changed slightly, because sites have been added and deleted from the NPL. These changes are not likely to affect the findings of this study. See the *Final Rule, National Priority List for Uncontrolled Hazardous Waste Sites*, October 14, 1992.[1]

Exhibit 2-3: Treatment and Disposal Decisions for Source Control at NPL Sites

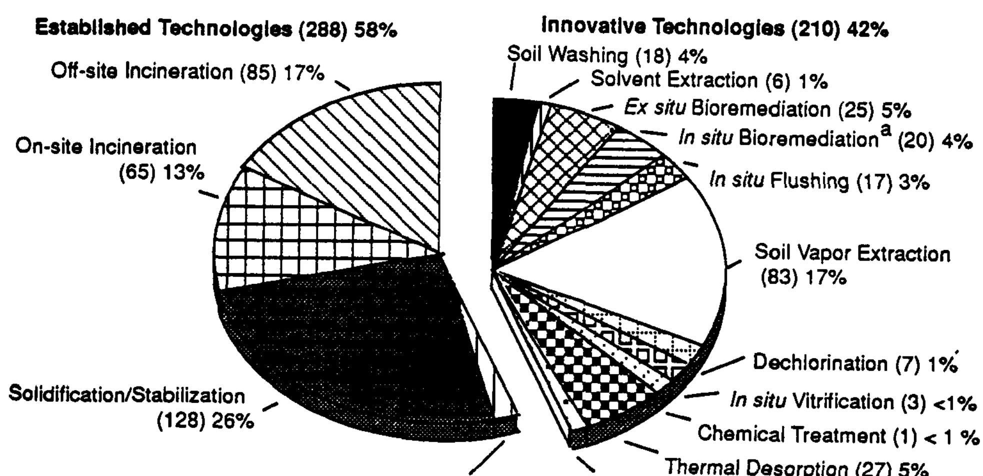


Notes:
- RODS = Records of Decision
- Appendix A, Exhibit A-1 contains supporting data.

Source: U.S EPA, Office of Emergency and Remedial Response, *ROD Annual Report, FY 1991*, April 1992.

Exhibit 2-4: Alternative Treatment Technologies Selected for NPL Sites Through Fiscal Year 1991

(Total Number of Treatment Technologies Selected is 498)



Notes:
- Data are derived from Records of Decision for fiscal years 1982-1991 and anticipated design and construction activities as of 1992. More than one technology per site may be used.

[a] Includes nine *in situ* ground water treatment technologies.

[b] "Other" established technologies are soil aeration, *in situ* flaming, and chemical neutralization. "Other" innovative technologies are air sparging and contained recovery of oily wastes.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA /542/R-92/011, October 1992.

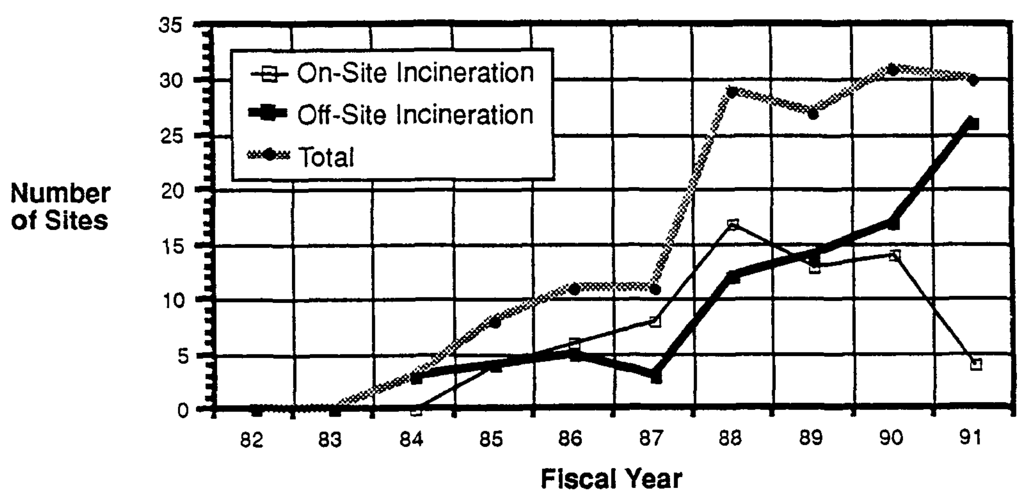
concentrate contaminants. Exhibit 2-5 illustrates trends in the selection of incineration. While the combined total for on-site and off-site incineration has been relatively constant over the past four years, in the past year the selection of on-site incineration has decreased.

Solidification/stabilization (also called "fixation" and "immobilization") is the second most popular technology to treat soil and other wastes. It is selected to remediate metal-containing waste and continues to be the favored technology to treat this material. It can treat most chemical forms of metals, although some compounds are not easily solidified. In some cases, it is selected to treat organic contaminants, primarily semi-volatiles (SVOCs). Although solidification/stabilization has several advantages, including low cost, questions remain concerning its effectiveness over time. Consequently, it may require long-term monitoring. Exhibit 2-6 illustrates selection trends for solidification/stabilization. Over the past five years, the selection frequency has fluctuated between 19% and 26% of source control RODs.

While existing technologies are being used successfully, new treatment technologies are needed that are less expensive and more effective.[3] "Innovative" treatment technologies are treatment methods for which performance and cost data are inadequate to support routine use. Brief definitions of innovative technologies selected at Superfund sites are provided in Appendix D.[b]

Exhibit 2-4 shows that of the 498 treatment technologies selected for source control, including nine for treatment of ground water *in situ*, 42% are considered innovative. In fiscal year 1991, for the first time, over half of the treatment technologies selected for source control were innovative (Exhibit 2-7) and in 30% of the RODs at least one innovative technology was selected.

Exhibit 2-5: On-Site and Off-Site Incineration Selected for NPL Sites

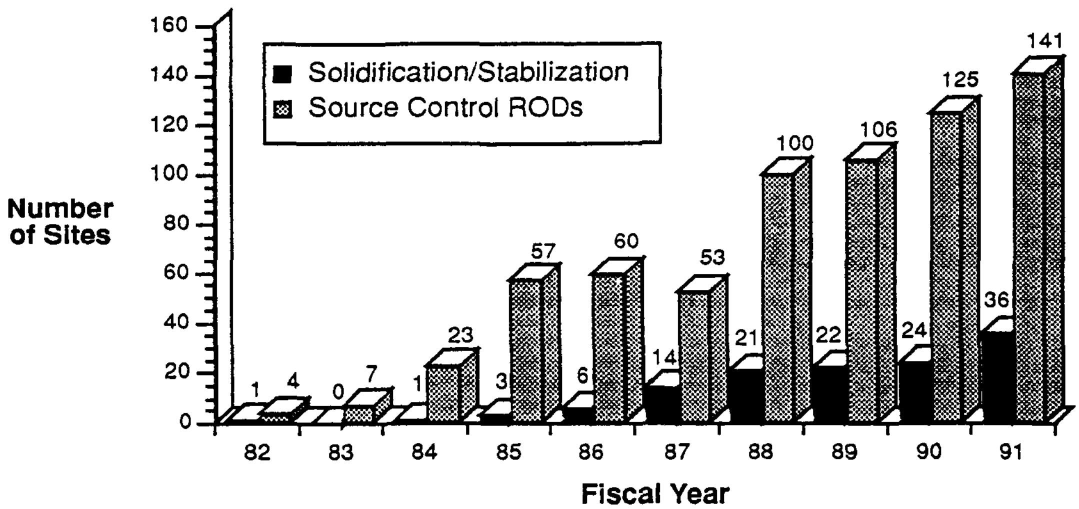


Note: Based on Records of Decision for fiscal years 1982-1991 and data on residuals management for innovative treatment technologies.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/540/2-91/001, April 1992.

[b] More information on innovative technologies is provided in an annual publication of the SITE program, which describes each technology participating in the program.[2] Many other publications on both innovative and established remedial technologies are listed in a bibliography compiled by EPA [4], and another compiled jointly by EPA and other federal agencies.[5]

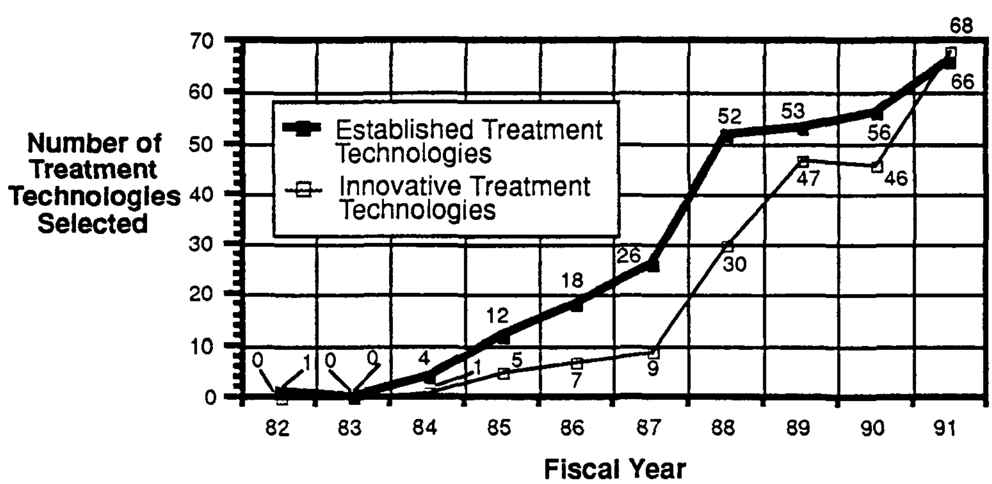
Exhibit 2-6: Solidification/Stabilization and Total Source Control Selected for NPL Sites



Note: Based on Records of Decision for fiscal years 1982-1991 and data on residuals management for innovative technologies.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/540/2-91/001, April 1992.

Exhibit 2-7: Number of Established and Innovative Treatment Technologies Selected for NPL Sites



Note: Data on innovative technologies are derived from Records of Decision for fiscal years 1982-1991 and anticipated design and construction activities as of October 1992. More than one technology per site may be used.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.

2.4 Contaminants at Superfund Sites with RODs

The selection of remedies at contaminated sites depends to a great extent on the types of wastes present. To gain a better understanding of the trends in selection of innovative technologies, an analysis of the contaminants and matrices that require remediation was conducted. Exhibit 2-8 shows that most NPL sites with RODs have both ground water contamination (79% of sites) and soil contamination (71% of sites). Contaminated sludge and sediments occur at 16% and 11% of these sites, respectively.

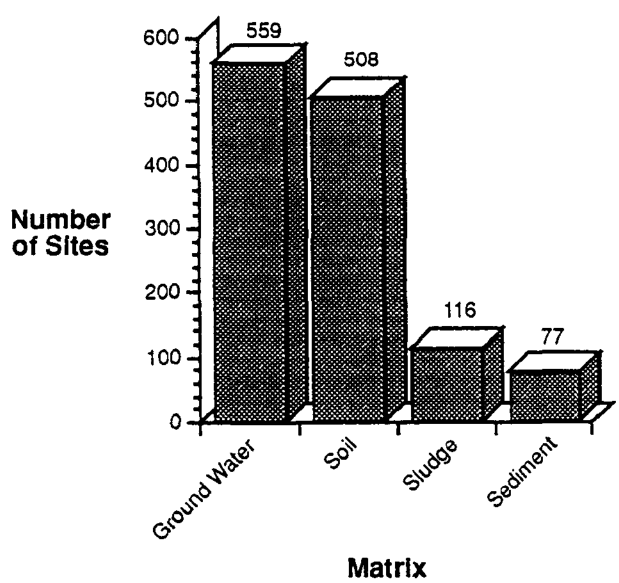
In this report, contaminants are placed into three major groups: volatile organic compounds (VOCs); SVOCs; and metals. Appendix A, Exhibit A-2, lists common chemicals in each group. With the exception of polychlorinated biphenyls (PCBs) and pesticides, which are grouped with SVOCs, chemicals and elements are grouped in accordance with EPA test methods for evaluating solid waste.[6] Metals are loosely defined to include most inorganics, including arsenic.

Data on the contaminants to be remediated are available for 687 of the 712 NPL sites with RODs. Exhibit 2-9 summarizes the incidence of the different contaminant groups at NPL sites with RODs. This analysis shows that VOCs occur at 75% of these sites, followed closely by SVOCs (73%) and metals (72%). These data also indicate that the NPL sites tend to be complex: all three groups are present at 48% of the sites, and at least two groups are present at an additional 25%. Analysis of data on the contaminants found in each matrix—ground water, soil, sediment, and sludge—shows that both metals and organics occur in ground water at 63% of sites with RODs and in soil at 66% of the sites (Exhibit 2-10).

2.5 Status of Innovative Technologies in Superfund

EPA's *Innovative Treatment Technologies: Semi-Annual Status Report* contains current information on each planned, ongoing, and completed innovative technology project selected for use in the Superfund program through fiscal year 1991.[7] It also contains information on a limited number of non-Superfund federal facility sites, primarily DOD and DOE sites. Most of the information on the selection and use of innovative technologies

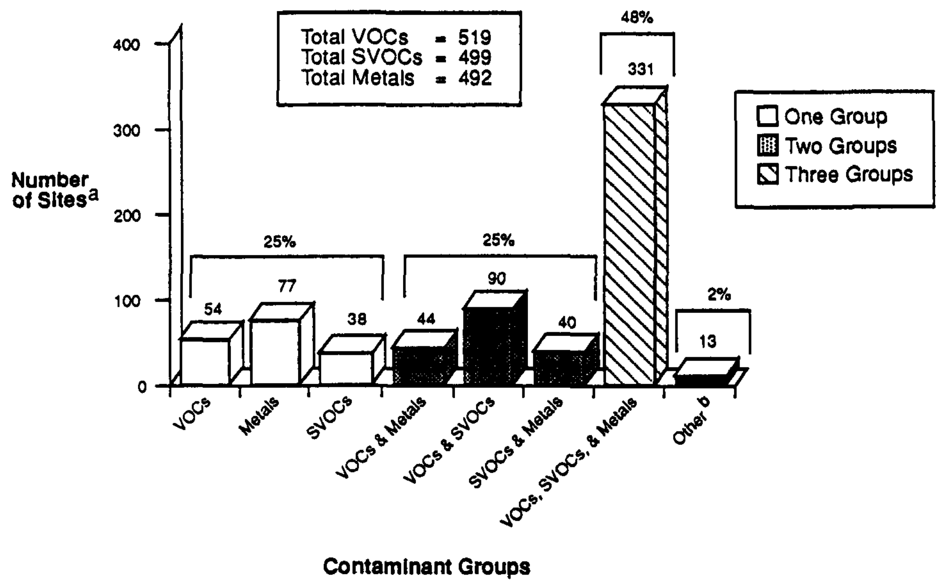
Exhibit 2-8: Frequency of Contaminated Matrices at NPL Sites with RODs



Note: More than one contaminated matrix may be present at each of the 712 sites that have signed Records of Decision.

Source: U.S. EPA, RODs, fiscal years 1982-1991.

Exhibit 2-9: Frequency of Major Contaminant Groups at NPL Sites with RODs



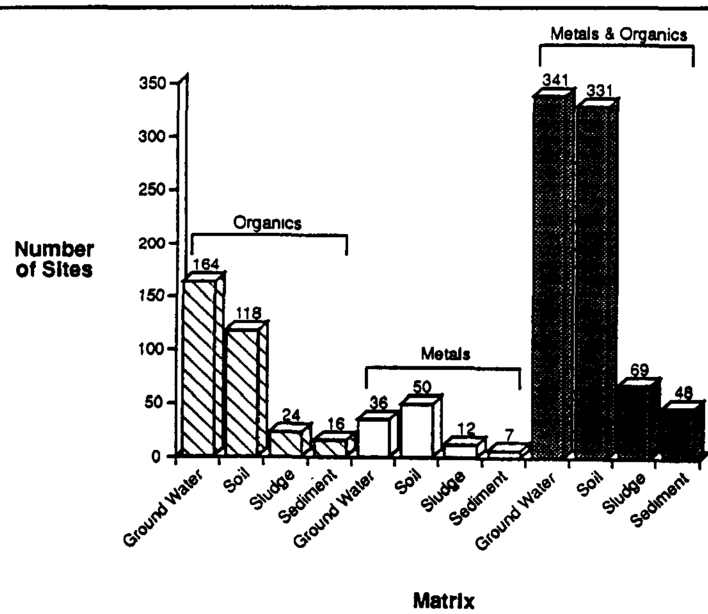
Notes:

[a] Contaminant information is available for 687 out of 712 National Priorities List sites that have signed Records of Decision. *Contaminant information is not available for 25 sites with RODs.*

[b] The 13 sites listed as "other" contain only explosives, non-metallic radioactives (*e.g.*, radon), nitrates, unspecified organics, asbestos, or chemical warfare agents.

Source: U.S. EPA, RODs, fiscal years 1982-1991.

Exhibit 2-10: Frequency of Organics and Metals by Matrix at NPL Sites with RODs



Note: Based on an analysis of 712 National Priorities List sites that have signed Records of Decision, of which 13 sites contain other contaminant types (*e.g.*, radon, asbestos, chemical warfare agents). Contaminant information for 25 sites is not available. Contaminants may occur in more than one matrix at a site.

presented in the remainder of this chapter is from this report.

Exhibit 2-11 provides the implementation status of innovative treatment technologies selected to remediate Superfund sites. Few projects using innovative technologies have been completed. Consequently, operating experience is limited for the more than 10 types of innovative technologies chosen at Superfund sites.

The innovative projects now in design probably will be implemented in the next few years. The average time between remedy selection (ROD) and implementation (remedial action) for *all types* of remedial actions is almost three years.[8] As these projects are implemented and completed, extensive information on full-scale performance of these technologies will become available through SITE program and other EPA reports.

2.6 Site Characteristics and Selected Remedies

Exhibit 2-12 shows how often innovative remedies have been selected at Superfund sites to treat VOCs, SVOCs, and metals. Although not reflected here, the presence of other contaminant groups or specific site conditions may also affect the technology selection. Most of these applications are for soil remediation; however, bioremediation includes nine projects for treating ground water *in situ*.

2.6.1 Volatile Organic Compounds (VOCs)

Of the three major contaminant groups, VOCs are the most frequently treated with innovative technologies. Innovative technologies have been selected to treat VOCs at 125 NPL sites with RODs. SVE was selected at 83 sites; bioremediation, 22 sites; thermal desorption, 20 sites; and *in situ* flushing, 11 sites.

Exhibit 2-11: Status of Innovative Technology Projects at NPL Sites as of October 1992

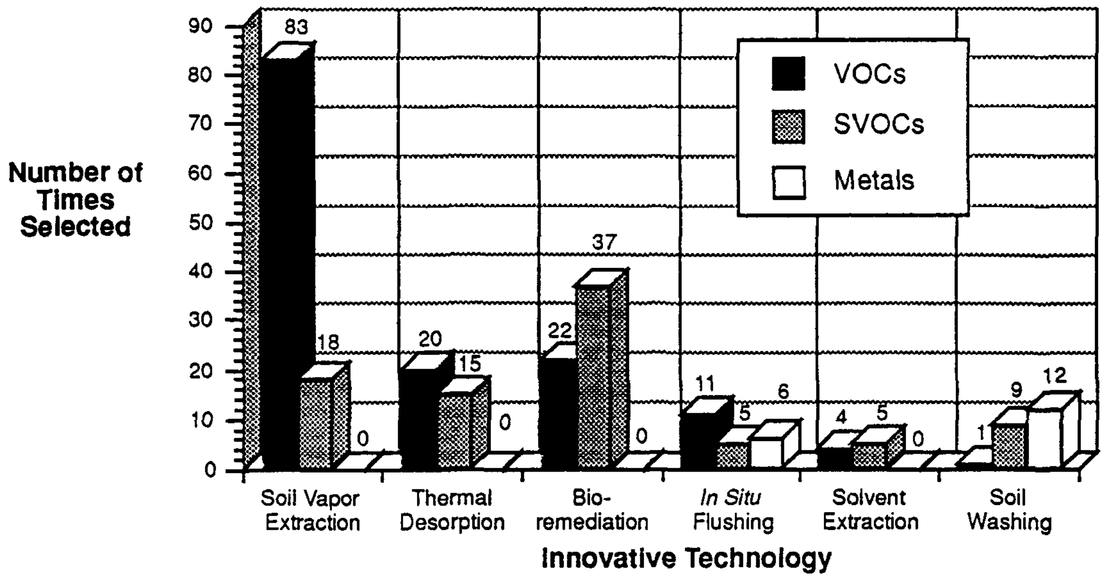
Technology	Predesign/ In Design	Design Complete/ Being Installed/ Operational	Project Completed	Total
Soil Vapor Extraction	62	18	3	83
Thermal Desorption	19	4	4	27
Ex Situ Bioremediation	17	7	1	25
In Situ Bioremediation[a]	14	5	1	20
Soil Washing	16	2	0	18
In Situ Flushing	12	5	0	17
Dechlorination	5	1	1	7
Solvent Extraction	5	1	0	6
In Situ Vitrification	3	0	0	3
Other Innovative Treatment	3	0	0	3
Chemical Treatment	0	0	1	1
TOTAL	156 (74%)	43 (21%)	11 (5%)	210 (100%)

Notes:
- Data are derived from Records of Decision for fiscal years 1982-1991 and anticipated design and construction activities.

[a] Includes *in situ* ground water treatment.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.

Exhibit 2-12: Applications of Innovative Treatment Technologies at NPL Sites



Note: At some sites, treatment is for more than one contaminant and more than one treatment technology may be used. Treatment may be planned, ongoing, or completed.

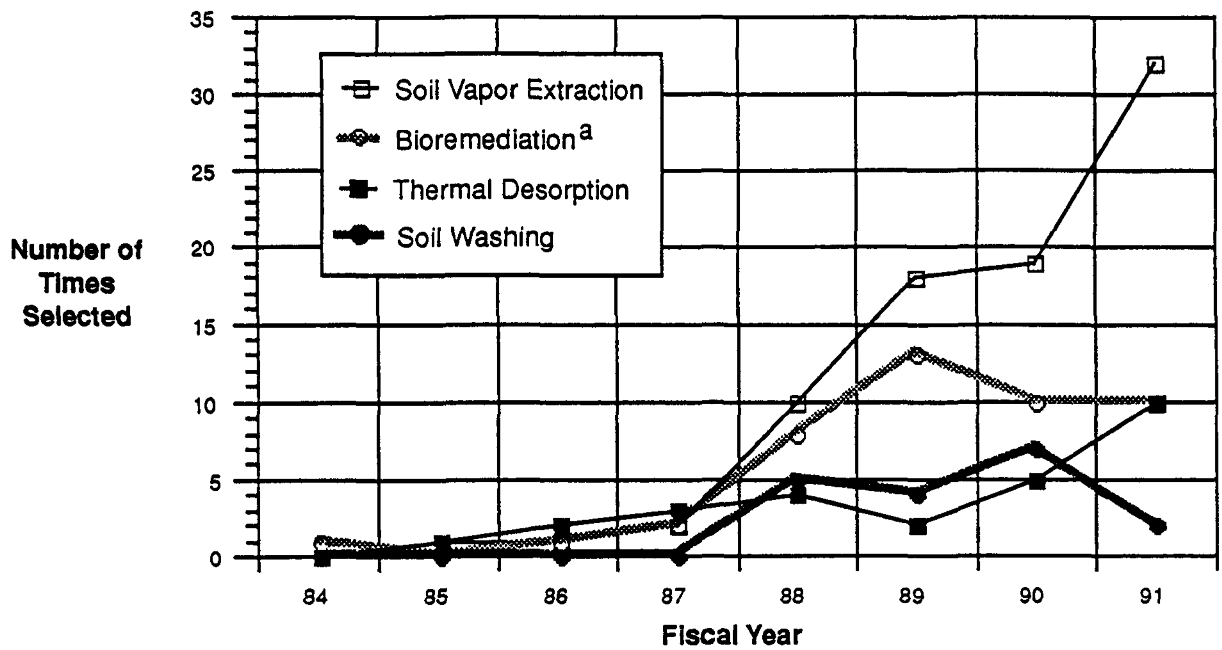
Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.

During the past four years, the use of SVE has increased far more than any other innovative technology (Exhibit 2-13). The increasing popularity of SVE is due to its low cost and the frequent occurrence of VOCs. Although performance varies from one application to another, SVE often is the most cost-effective means of reducing the concentration of VOCs. SVE has been selected in some cases to pretreat soils prior to excavation or subsequent treatment. At two sites, the use of SVE to enhance *in situ* bioremediation (called "bioventing") is being explored. Bioventing optimizes SVE performance by improving the biodegradation of certain VOCs by increasing the air flow. Bioventing also may increase SVE use when VOCs and SVOCs are present. SVE removes the VOCs, while bioventing degrades the SVOCs. Other developments that may expand the application of SVE include radio frequency heating, horizontal wells, and methods to increase soil permeability.

Despite its frequent selection, SVE is still considered innovative because its effectiveness has not been confirmed for many types of sites and contaminants. Only three SVE projects have been completed at NPL sites and only four are operational. SVE is very effective in removing organic contaminants located in the pore spaces of the soil matrix or that are adsorbed onto accessible soil surfaces. However, SVE is not effective in removing contaminants that are entrapped within the soil matrix. Entrapped VOCs are often found at sites with long-standing soil contamination.[9]

Bioremediation and thermal desorption appear to be the favored innovative technologies to treat sites where VOCs occur with SVOCs. Bioremediation has been chosen 22 times to treat VOCs, primarily nonchlorinated VOCs, such as benzene. In all but five cases, SVOCs also are being treated. Thermal desorption has been selected 20 times to address VOCs, and in eight of these cases SVOCs are being treated as well. At five sites, thermal desorption has been selected to separate organics from metals prior to solidification/stabilization of the metal-containing residuals.

Exhibit 2-13: Trends in the Selection of Innovative Treatment Technologies at NPL Sites



Note:
[a] Includes sites using *ex situ* or *in situ* bioremediation of source material or *in situ* bioremediation of ground water.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status*

2.6.2 Semi-Volatile Organic Compounds (SVOCs)

Innovative technologies have been selected to remediate SVOCs at 77 sites with RODs. Bioremediation has been the most frequently selected innovative technology for SVOCs, accounting for 37 sites. SVE has been selected for some of the more volatile SVOCs (*e.g.*, phenols and naphthalenes) at 18 sites and thermal desorption has been selected for SVOCs at 15 sites. Other technologies used to treat SVOCs are *in situ* flushing, soil washing, solvent extraction, and dechlorination (not shown in the exhibit).

Bioremediation is the second most frequently selected innovative technology. Its selection has remained relatively constant over the past several years. The methods selected include land treatment, aqueous-based *in situ* treatment, and slurry-phase treatment. Bioremediation has been selected at 27 sites to treat polynuclear aromatic hydrocarbons (PAHs), at 18 sites to treat other SVOCs, and at 22 sites with VOCs. Two bioremediation projects are completed and 11 are operational. In both 1990 and 1991, bioremediation was chosen about 10 times (Exhibit 2-13).

Since bioremediation destroys organic contaminants, it has a major advantage over other innovative technologies that rely on separation techniques. The reason that bioremediation has not been selected more often at Superfund sites is probably because, in its current state of development, it addresses a limited number of biodegradable compounds. It also may have difficulty meeting stringent cleanup levels or may require long periods of time to achieve the required reductions. However, current research efforts are likely to improve performance and to expand the types of contaminants amenable to biological degradation. Also, the use of air-based methods—bioventing and air sparging—to provide oxygen to soil and ground water, should increase the use of *in situ* bioremediation.

Thermal desorption treats a broad spectrum of VOCs and SVOCs. PCBs are treated by thermal desorption more often than any other SVOC. Four thermal desorption projects have been completed. Thermal desorption may be particularly well-suited for separating organics from metals. Soil washing has been selected nine times to treat SVOCs, such as PAHs, phenols and pesticides, but no soil washing projects have been completed at Superfund sites. Dechlorination, a form of chemical treatment, also has been selected to treat PCBs at seven sites, one of which has been completed. Four of these sites concern soil, while the remainder involved the treatment of residues from separation technologies.

Thermal desorption and soil washing are the most popular means of separating or concentrating organic waste that require further treatment. The combined use of several treatment technologies in a series (called "treatment trains") is designed to: reduce the volume of material requiring subsequent treatment; prevent emission of volatile contaminants during excavation and mixing; or address multiple contaminants within the same medium. Treatment trains have been selected at 43 Superfund sites (including removal actions); 35 of these sites use innovative technologies for one or more of the treatment steps (Exhibit 2-14). An additional eight sites use established technologies, primarily solidification/stabilization of incineration residues.

2.6.3 Metals

The most frequently selected technology for metal waste is solidification/stabilization, which has been selected at 128 sites. Innovative technologies have

Exhibit 2-14: Treatment Trains of Innovative Treatment Technologies Selected for Remedial and Removal Sites

First Technology	Subsequent Technology	Number of Applications
Soil Washing	Bioremediation or Incineration or Solidification/Stabilization	7 Sites 3 Sites 1 Site
Thermal Desorption	Incineration or Solidification/Stabilization or Dechlorination	4 Sites 5 Sites 2 Sites
Soil Vapor Extraction	*In Situ* Bioremediation or *In Situ* Flushing or Solidification/Stabilization or Soil Washing	1 Site 1 Site 1 Site 1 Site
Dechlorination	Soil Washing	1 Site
Solvent Extraction	Solidification/Stabilization or Soil Washing or Incineration	2 Sites 1 Site 1 Site
Bioremediation	Solidification/Stabilization	2 Sites
In Situ Flushing	*In Situ* Bioremediation	1 Site
Chemical Treatment	*In Situ* Bioremediation	1 Site

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.

been selected at 20 sites containing metals. Soil washing has been selected at 10 sites to remediate chromium, lead, copper, barium, silver, cadmium, and arsenic. *In situ* flushing has been selected at six sites to treat chromium, lead, nickel, arsenic, and mercury. The application of this technology is largely dependent on site hydrogeology.

No treatment technologies have yet been selected at NPL sites with low-level radioactive metals combined with other hazardous constituents (known as "mixed wastes"). In the past, the selected remedy has been excavation and on-site storage or disposal in an off-site landfill permitted to accept such waste. DOE is testing several technologies to address radioactive contaminants.

2.6.4 Metals and Organics Combined

Typically, treatment trains are used to address media and wastes containing both metals and organics. Some of the most frequently-selected treatment trains for these wastes using innovative technologies include soil washing or thermal desorption followed by solidification/stabilization. Solvent extraction is another technology potentially applicable to mixed organic and metal waste; however, it has not gained the same level of acceptance as thermal desorption. In a few cases, innovative technologies have been selected to treat both metals and organics simultaneously. *In situ* flushing is being used for both metals and organics at three sites. Also, *in situ* vitrification has been selected for both metals and organics at three sites.

2.6.5 Waste Matrix

Of the 210 innovative technologies selected at Superfund sites, 198 technologies concern source control and nine technologies are for the treatment of ground water *in situ*. The innovative source control technologies address soil at 83% of the sites, sediments at 13%, sludge at 8%, and solids at 3%. The total exceeds 100% because each technology may be used to treat more than one waste matrix at a site.

The quantities of soil treated by the various innovative techniques varies widely from one site to another (Exhibit 2-15). In general, *in situ* technologies such as *in situ* flushing, SVE, and *in situ* bioremediation can treat larger volumes of soil. Technologies that treat excavated wastes or require waste post-processing (*e.g.*, soil washing, thermal desorption, and solvent extraction) generally are selected to treat smaller amounts of soil.

Exhibit 2-15: Quantities of Waste to be Treated By Innovative Technologies at NPL Sites

Technology	Number of Superfund Sites With Data (Without Data)		Quantity (Cubic Yards)		
			Range	Average	Total
In Situ Bioremediation[a]	9	(2)	5,000 - 260,000	110,000	1,200,000
In Situ Flushing	12	(5)	5,200 - 650,000	81,000	980,000
Soil Vapor Extraction	54	(29)	70 - 300,000	59,000	3,200,000
Soil Washing	18	(0)	1,800 - 160,000	47,000	840,000
Thermal Desorption	27	(0)	1,600 - 130,000	29,000	780,000
Ex Situ Bioremediation	20	(5)	700 - 600,000	35,000	700,000
Solvent Extraction	6	(0)	2,000 - 67,000	26,000	160,000
Dechlorination	5	(2)	700 - 50,000	23,000	120,000
In Situ Vitrification	3	(0)	2,000 - 10,000	6,000	19,000
				Total	8,000,000

Note:
[a] Does not include *in situ* ground water treatment.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.

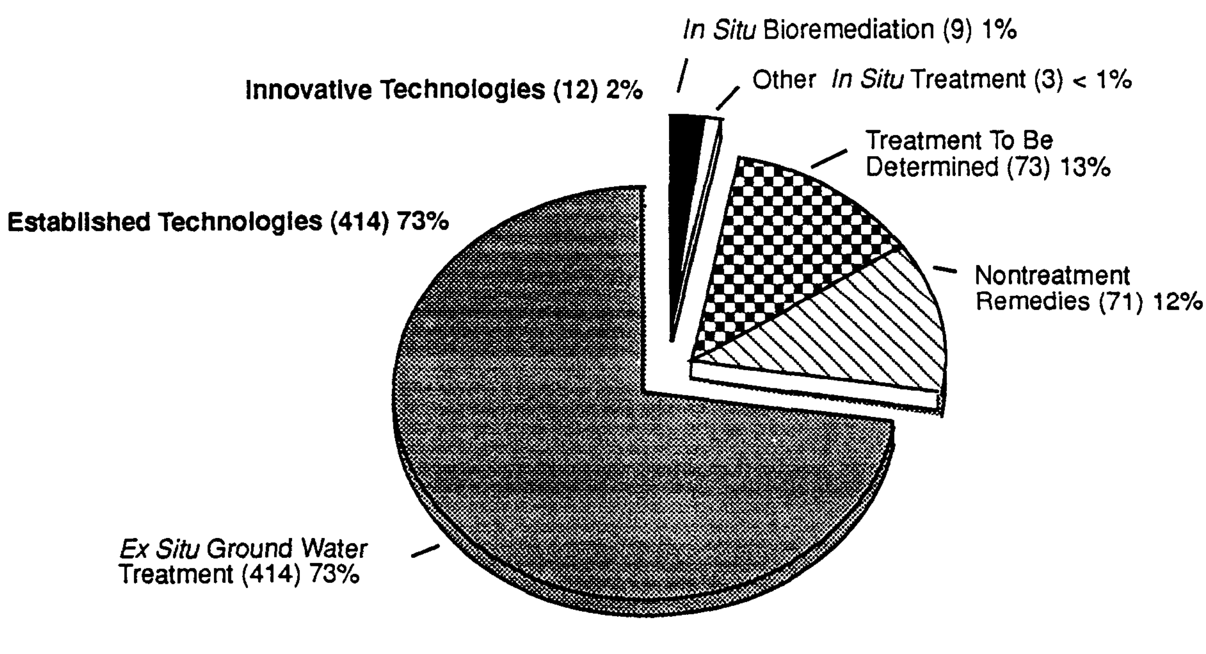
Although 79% of Superfund sites with RODs require ground water remediation, *in situ* ground water remedies make up less than 2% of the ground water technologies selected at Superfund sites (Exhibit 2-16). Of the nine sites for which *in situ* bioremediation for ground water has been selected, five contain nonchlorinated volatiles (*i.e.*, benzene, toluene, ethylbenzene, xylene), five contain SVOCs, and one has chlorinated VOCs. In most cases, ground water is pumped to the surface to be treated by conventional physical/chemical methods. Some innovative approaches are being developed for above-ground aqueous treatment, such as laser-induced oxidation and solar detoxification.

Recent studies show that pump-and-treat technology alone is often insufficient to meet cleanup goals.[10] Until recently, contaminants in unsaturated soils were considered to be the most significant source of ground water contamination. However, studies indicate that nonaqueous phase liquids (NAPLs) and contaminants captured or sorbed by soils in the aquifer are released slowly into the ground water. Consequently, improved *in situ* ground water remediation technologies are needed to treat this residual subsurface contamination.[11]

2.7 Conclusions

Current trends in the selection of treatment technologies in the Superfund program indicate that established and innovative technologies are being used about equally. Although innovative technologies are gaining popularity, in fiscal year 1991 one-half of the treatment technologies selected were still the established technologies—primarily incineration and solidification/stabilization. These technologies are applicable to a wide range of contaminants and site characteristics. The search for alternatives to incineration has led to new technologies; however, the low cost of solidification/stabilization probably has slowed the development of innovative approaches.

Exhibit 2-16: Ground Water Remedies at NPL Sites Through Fiscal Year 1991



Note: Often more than one ground water technology is selected.

Source: U.S. EPA, Technology Innovation Office, *Innovative Treatment Technologies: Semi-Annual Status Report*, EPA/542/R-92/011, October 1992.
U.S EPA, Office of Emergency and Remedial Response, *ROD Annual Report: FY 1991*, April 1992.

The selection of innovative technologies for Superfund cleanups is increasing and niches for specific technologies have begun to emerge. Most of the innovative technologies selected treat organic contamination. Selection of SVE, which is applicable to VOCs, has increased sharply in the last several years. Enhancements, such as methods to increase soil permeability, may expand its applicability and improve performance. The selection of thermal desorption also is increasing, but more slowly than SVE. Applications for this technology include VOCs, particularly when SVE is not feasible, and PCBs. Soils containing both metals and organics—especially those with a high volatilization temperature—present another major opportunity. The residuals containing metals then can be solidified/stabilized. The increasing use of thermal desorption is part of a trend toward greater use of treatment trains.

Bioremediation is the second most frequently selected innovative technology and its selection has remained constant over the past several years. This trend may reflect a limitation in the number of sites with contaminants that can be treated by bioremediation in its current state of development. Current research into bioremediation, and more use of air-based methods (*e.g.*, bioventing, air sparging) to aerate soil and ground water in place, are likely to improve performance and to expand the types of contaminants amenable to biological degradation. Of the other technologies selected to treat only organic compounds, dechlorination and solvent extraction have been selected at a few sites, primarily to treat PCBs. A small number of *in situ* ground water treatment technologies have been selected to treat organic compounds. This indicates a lack of demonstrated *in situ* treatment options.

Few innovative treatment methods are being selected for metals. Soil washing, a preprocessing technology, is being selected to concentrate either metals or SVOCs present in soil. *In situ* flushing has been selected for both metals and organics. *In situ* vitrification also has been selected at a handful of sites to treat organics, metals, or both. New separation technologies are needed to reduce waste quantities and allow recycling of metals.

Historical trends can serve as a guide to future selection trends. However, the hazardous waste remediation industry is evolving rapidly as a result of research and experience. Consequently, future applications will probably vary from current trends.

2.8 References

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2. U.S. Environmental Protection Agency, Office of Research and Development, "The Superfund Innovative Technology Evaluation Program: Technology Profiles", Fifth Edition, EPA/540/R-92/077, December 1992.

3. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Furthering the Use of Innovative Treatment Technologies in OSWER Programs," OSWER Directive 9380.0-17, June 10, 1991.

4. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation (A Bibliography of Information Sources)," EPA/542/B-93/001, January 1993.

5. U.S. Environmental Protection Agency, *et al*, "Federal Publications on Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation," Second Edition, prepared by the member agencies of the Federal Remediation Technology Roundtable, 1992.

6. U.S. Environmental Protection Agency, "Test Methods for Evaluating Solid Waste, Volume 1A: Laboratory Manual, Physical/Chemical Methods," Third Edition, Proposal Update Package, NTIS No. PB89-148076, November 1987.

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9. U.S. Department of Energy, Oak Ridge National Laboratory, "An Evaluation of Vapor Extraction of Vadose Zone Contamination," ORNL/TM-12117, May 1992.

10. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Evaluation of Ground Water Extraction Remedies: Phase II," Volume 1, November 1991.

11. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "*In Situ* Treatment of Contaminated Ground Water: An Inventory of Research and Field Demonstrations and Strategies for Improving Ground-Water Remediation Technologies," Presented at the Air and Waste Management Association/U.S. EPA Symposium on Site Treatment of Contaminated Soil and Water, February 4-6, 1992.

CHAPTER 3
DEMAND FOR REMEDIATION TECHNOLOGIES AT NATIONAL PRIORITIES LIST SITES

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, known as Superfund, EPA manages or oversees the cleanup of some of the most contaminated abandoned hazardous waste sites in the nation.[a] As of September 30, 1992, EPA has listed 1,275 sites on the National Priorities List (NPL), and forty sites have been deleted (usually because cleanup is completed), resulting in a current total of 1,235.[b] Also, it is anticipated that between 400 and 800 additional sites will be added by the year 2000. Although this number is small compared to the number of sites addressed through other programs (*e.g.*, RCRA corrective action, leaking underground storage tank, federal and state remediation programs), these sites are an important market for remediation technologies. Because Superfund sites are generally at later stages of decision-making or cleanup, they represent a relatively large market in the near term, as well as a valuable source of site characterization information.

In this report, the Superfund market for remediation technologies is divided into three segments—short-term demand, intermediate-term demand, and long-term demand (Exhibit 3-1). The short-term demand, which includes sites where remedies have already been selected, is discussed at length in Chapter 2. The intermediate-term demand consists of those NPL sites where remedies have not been selected. This chapter presents analyses of the number, location, and size of these sites and the types of contaminants and matrices present. This information is used to indicate the potential intermediate-term demand for specific cleanup technologies. The long-term demand includes sites anticipated to be listed on the NPL through the year 2000. Because these sites have not yet been identified, the numbers of sites presented here are estimated.

This chapter also presents estimates of the cost of cleaning up EPA sites; programmatic factors that may affect the NPL market; and other factors affecting remedy selection, remedy design, and procurement.

3.1 Factors Affecting Demand for NPL Site Cleanup

Some of the factors that impact estimates of NPL cleanup demand are discussed below.

- As of the end of fiscal year 1991, 523 sites did not have a signed ROD. These sites are the basis for most of the analysis in this chapter. Subsequent to this analysis, in fiscal year 1992, EPA signed RODs for about 80 of these sites.

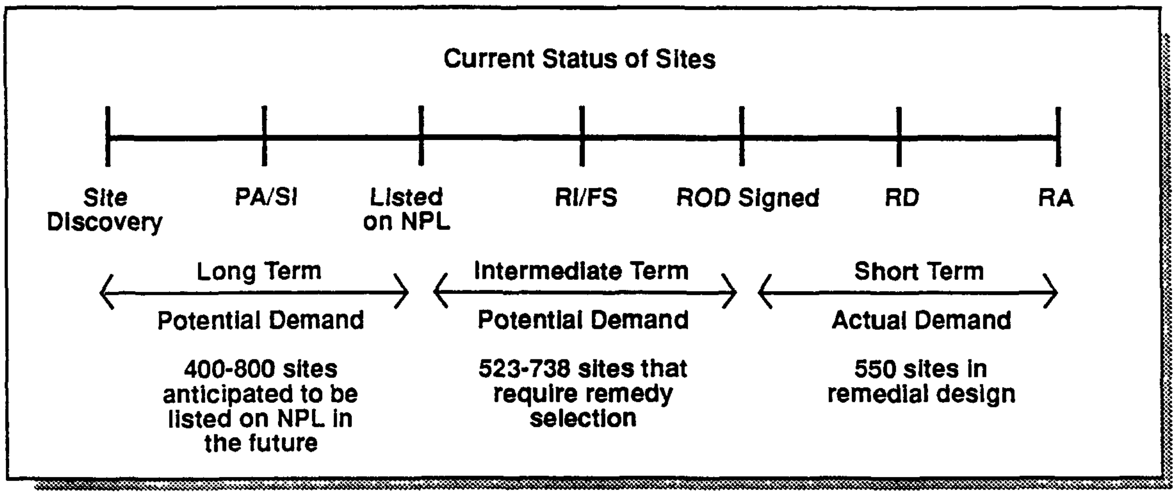
- The EPA has conducted 2,155 removal actions at both NPL and non-NPL sites. It is difficult to predict the number, type, and timing of the cleanup of these sites. Removals, which are usually limited to one year and $2 million, historically have relied less on innovative technologies than have longer term remedial actions. Because only about 18 innovative technologies have been used for removal actions to date, data on removal actions are not included in this report.[2]

- Federal, state, and PRP funding for Superfund site cleanups may fluctuate in the future. For Superfund remedial action, the states contribute 10% of the construction and operation costs. Also, PRP contributions to site remediation may be affected by business conditions.

[a] Chapter 2 provides a description of CERCLA and the Superfund process.

[b] Subsequent to this analysis, these totals have changed slightly, because sites have been added and deleted from the NPL. These changes are not likely to affect the findings of this study.[1]

Exhibit 3-1: Demand for All Types of Remediation Services at NPL Sites



Notes:

- Data as of September 30, 1991.
- Short term includes National Priorities List (NPL) sites for which some type of technology (including treatment, containment, and disposal) will be implemented within three to four years. Intermediate term includes NPL sites for which remedies were not selected as of September 30, 1991. Remedial actions are expected to be implemented within three to eight years. Long term includes sites anticipated to be added to the NPL by the year 2000, and to be remediated in 8 to 16 years.
- Status of cleanup:

PA	Preliminary Assessment	ROD	Record of Decision
SI	Site Inspection	RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study	RA	Remedial Action

3.2 Summary of Methods

The demand for remediation services at NPL sites is estimated from information on the characteristics, status, and technology trends for sites currently on the NPL. The following analyses were conducted:

- General site descriptions, sources of contamination, types of contaminants, and matrices contaminated for the 523 sites without RODs, were derived from site assessment (PA/SI) data as of the end of fiscal year 1991. These data were extracted from the descriptions published when a site is proposed for addition to the NPL.[c] During a PA/SI, a limited number of samples of ground water, soil, sludge, or other potentially contaminated material are taken and analyzed for the presence of priority pollutants. Information also is gathered on the potential sources of the contamination.

- Information on the characteristics of the NPL sites with RODs were derived directly from the RODs. RODs usually include summary information on the extent of contamination (contaminants, concentrations, and quantities) obtained from the RI/FS. The ROD data were compared to the PA/SI site characteristics and used to characterize the matrices that may require remediation at intermediate-term sites.

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[c] Information on these sites is listed in Appendix A, Exhibit A-3.

- Information from RODs is used to estimate the quantities of waste at the sites without RODs. This step is necessary because the PA/SI information is not sufficient to estimate quantities of contaminated materials to be remediated.

Other sources of information include References two through seven, which are listed in Section 3.9, References.

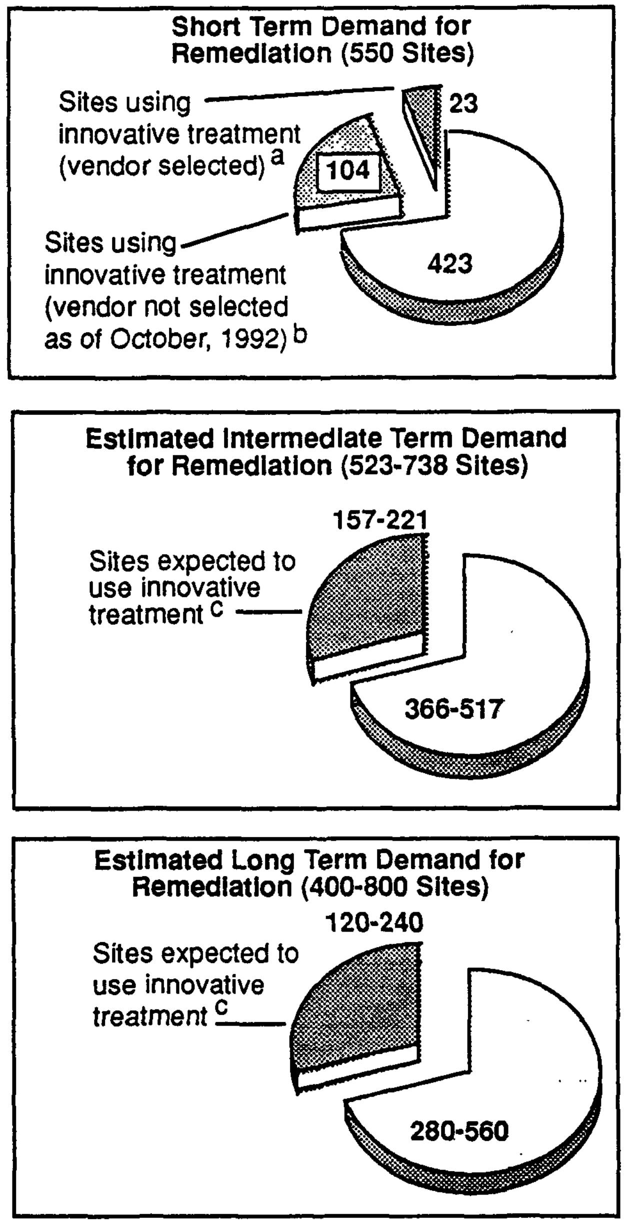
3.3 Major Components of the NPL Market

For this report, the Superfund market for remedial technologies has been divided according to the approximate time period in which most of the remedial work is likely to be done. Exhibit 3-1 shows the number of sites in each NPL market component. Although the number of these sites that will use innovative technologies is uncertain, projections are shown in Exhibit 3-2. These projections are based on technology selection trends over the past year and are believed to be conservative, since the relative use of these technologies has been growing. The scope of these markets is summarized below.

3.3.1 Short-Term Demand

Short-term demand for remedial technologies arises from the NPL sites where some type of remedial technology has been specified in a ROD, but has not yet been implemented. Chapter 2 addresses the technologies selected for sites with RODs through September 30, 1991.

Exhibit 3-2: Minimum Demand for Innovative Treatment at NPL Sites



Notes:
[a] Includes three sites using *in situ* ground water technology.
[b] Includes nine sites using *in situ* ground water technology.
[c] Based on recent trends that indicate that at least 30% of future sites will use innovative technologies.

Most sites for which remedies have been selected, but not implemented, are in remedial design (RD). Based on CERCLIS, about 550 NPL sites were in RD as of September 30, 1991.[8] EPA estimates that most of these 550 sites will enter the remedial action (RA) phase within the next three or four years. Although the selection of a cleanup contractor for EPA-lead sites typically occurs after the RD has been completed, vendors have been chosen for some of the 550 sites. As of October 1992, a total of 158 innovative technology applications had been selected for 127 of these sites (Exhibit 3-2). For at least 23 of these sites, RPs have already selected vendors. The number of the other 423 sites that have designated vendors is not known. These 423 sites are considered to be a portion of the short-term demand for remedial technologies.

3.3.2 Intermediate-Term Demand

Intermediate-term demand includes an estimated 523-738 NPL sites that will begin remedial action in three to eight years (Exhibit 3-2). The minimum number, 523, represents sites for which remedies have not been chosen. In addition, 215 sites for which a ROD has been signed will require at least one additional ROD to complete the cleanups.[3]

The number of remedial projects that will use innovative technologies is estimated based on recent trends. Last year, 30% of the RODs for NPL sites have selected at least one innovative treatment technology for source control.[2] Because the selection and use of innovative technologies for source control has been increasing steadily, the estimate that 30% of future sites will apply innovative technologies is considered a reasonable minimum. Thus approximately 157-221 sites will use innovative technologies. These projections do not include *in situ* ground water remediation. Although *in situ* ground water treatment represents a large potential market for innovative technologies, the data do not allow accurate predictions of this demand.

3.3.3 Long-Term Demand

The NPL is expected to grow by 50-100 sites per year, potentially reaching 2,000 sites (or an additional 400-800 sites) by the year 2000. These sites are considered the long-term demand for remediation. Cleanups for these sites will begin in eight to 16 years.

Because there are little data available for long-term sites, most of the remaining analysis in this chapter relies on data from the intermediate-term sites. Although the general nature of the long-term sites is expected to be similar to that of the intermediate-term sites, the characteristics of these sites may differ somewhat from those currently on the NPL, because future sites will be evaluated under the new Hazard Ranking System (HRS). The sites currently listed on the NPL were ranked under the original HRS, which emphasized exposure to contaminated ground water. The revised HRS also ranks sites for soil exposure and other new factors.[9] Using the 30% estimate, 120-240 long-term sites will initiate cleanup using innovative technologies for source control.

3.4 Characteristics of Intermediate-Term Demand Sites

Exhibit 3-3 presents the geographical location of the 523 sites that do not have signed RODs. The data reflect the industrialized nature of these regions and the number of abandoned industrial and commercial facilities. Michigan, New Jersey, and New York alone account for 30% of these NPL sites.

Appendix A, Exhibit A-3 lists the state, contaminant groups, and matrix of concern available from site assessments, as well as the planned date for signing the ROD for the 523 sites. Because further site characterization and risk assessment are required to determine which wastes will actually require remediation, these data serve only as an overall indication of the nature of site contamination. The characteristics of these sites are presented in this section.

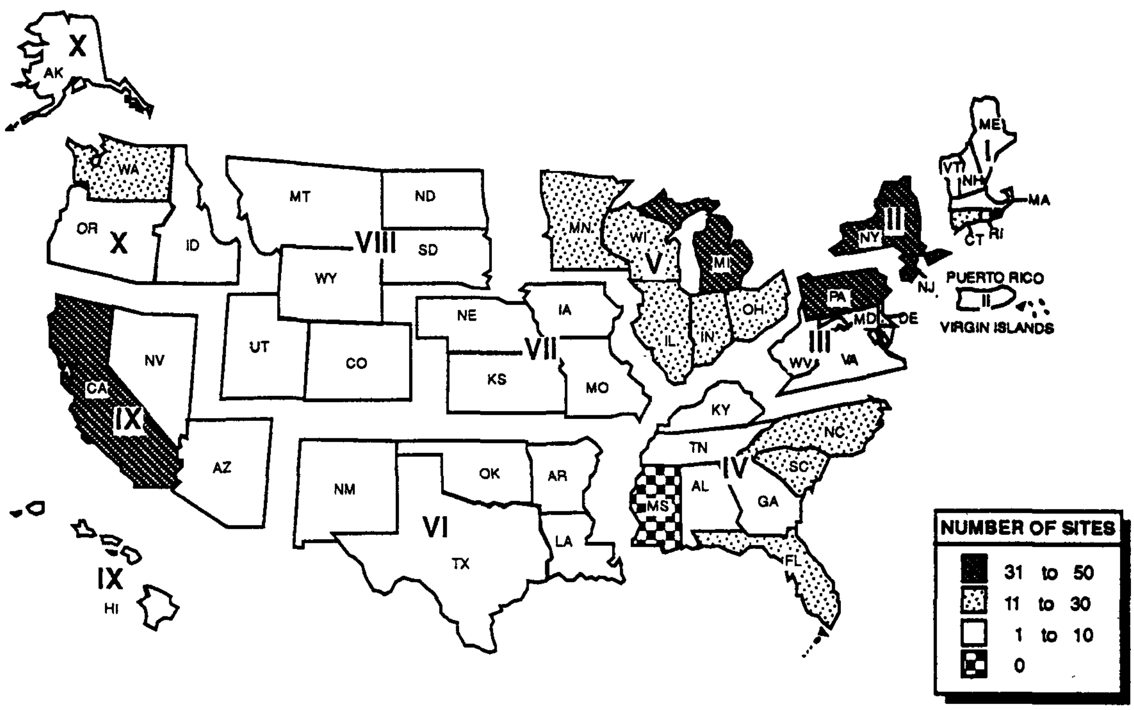
3.4.1 Types of Contaminated Matrices

Based on data from the 712 NPL sites with RODs, an estimated 80% of intermediate-demand sites may require remediation of ground water, 74% of soil, 15% of sediments, and 10% of sludge. Available data do not allow estimates of the number of sites containing other types of wastes, such as waste piles, mine tailings, and liquid wastes. Because the original HRS emphasized ground water, the PA/SI data may not account for other contaminated matrices at these sites. By contrast, the ROD data consist of information gathered in the more detailed RIs, and are more likely to represent the occurrence of all contaminated matrices at *all* NPL sites. Thus, ROD data were used to characterize contaminated matrices at intermediate-term sites.

3.4.2 General Site Descriptions and Contaminant Sources

Exhibit 3-4 summarizes the ownership and historical uses of the 523 NPL sites for which remedy selections are still pending. This exhibit lists the most prevalent activities at these sites (as

Exhibit 3-3: Location of NPL Sites Without RODs



Notes: Includes 523 National Priorities List (NPL) sites without Records of Decision. Roman numerals indicate U.S. EPA Regions.

Source: U.S. EPA, Office of Emergency and Remedial Response, CERCLIS Database, 1992.

documented in the PA/SIs), and, thus, activities most likely to have resulted in contamination. Appendix D provides descriptions of industries represented by each source in the exhibit.

Most of the sites were industrially owned or operated, and a variety of industrial activities are represented. According to the available data, 60% of the sites contain waste from only one type of industry. However, these data may oversimplify the complexity of Superfund site contamination, because the PA/SI may not identify all prior site uses and sources of contamination. Also, many types of contaminants may be associated with the same industrial source.

3.4.3 Types of Contaminants

The types of contaminants present play a major role in the selection of a technology. For the 523 sites without RODs, the PA/SIs are the only source of readily available data. However, the PA/SI data are best used to provide a general indication of contaminant frequency. Further site-specific analysis may reveal that these contaminants are not a threat and do not require treatment. To aid in interpreting the PA/SI data, the ROD data (based on the 712 NPL sites with RODs discussed in Chapter 2) were compared with the data for 523 NPL sites without RODs. RODs document contaminants that pose a threat and require remediation.

3.4.3.1 Major Contaminant Groups

Exhibit 3-5 presents the frequency of occurrence of the major contaminant groups at the 523 sites without RODs. The exhibit presents the number of sites with one group, the occurrence of two groups at the same site, and the occurrence of three groups.

A similar analysis was conducted for sites with signed RODs, and is discussed in Section 2.4 of this

Exhibit 3-4: Summary of NPL Site Descriptions and Sources of Waste for Sites Without RODs

SITE DESCRIPTION	NUMBER OF SITES
Industrially Owned or Operated Facilities	239
Commercial Hazardous Waste Management Facilities	93
Federal Facilities	78
Uncontrolled Dump Sites	54
Municipal Landfills	49
Recycling/Reclamation Facilities	10
TOTAL SITES [d]	523

INDUSTRIAL SOURCES OF WASTE	NUMBER OF SITES
Organic Chemical Manufacturing	70
Fabricated Metal Products	64
Metal Plating	41
Electronic/Electrical Equipment Manufacturing (mostly semiconductor)	41
Inorganic Chemicals Manufacturing	32
Paints and Coatings Manufacturing	27
Agricultural Production and Services	27
Primary Metal Products Manufacturing	23
Wood Preserving Processes	20 [a]
Rubber and Plastics Products Manufacturing	19
Petroleum Refining	15
Solvent Reclamation	15
Used Oil Reclamation	13
Other Sources [b]	62
Other Manufacturing [c]	201
TOTAL OCCURRENCES [e]	670

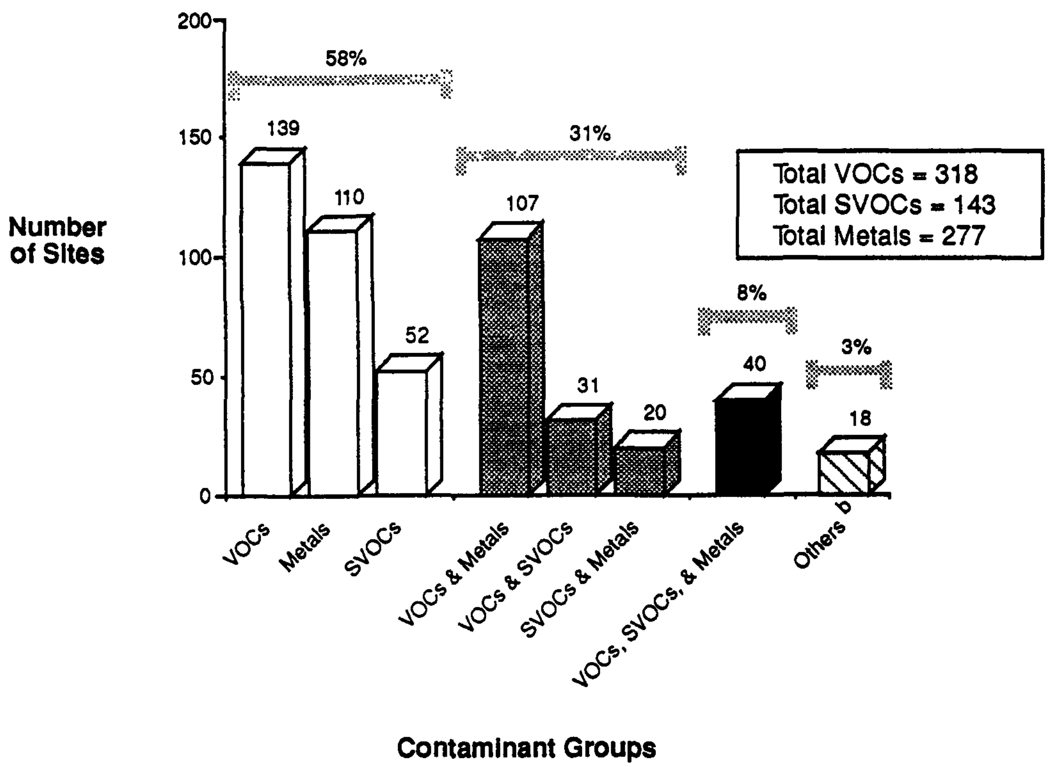
Notes:
[a] U.S. EPA anticipates that this number may increase as a result of the Wood Preserving Final Rule (*Federal Register*, Vol. 55, No. 235).
[b] Other sources include: metals mining (11), non-metals mining (6), oil and gas (3), construction (3), and not specified (39).
[c] Type of manufacturing was not specified in the site descriptions.
[d] One site description was assigned for each site.
[e] Out of 523 National Priorities List sites without Records of Decision, industrial sources were available for 446 sites, two industrial sources were identified for 126 sites, and three sources for 49 sites, for a total of 670 sources.

Source: U.S. EPA, Technology Innovation Office, site assessment data, 1992.

report. A comparison of the data in Exhibits 2-8 and 3-5 shows some significant differences in the types and combinations of contaminants present.

The major differences in the data are with semi-volatile organic chemicals (SVOCs) and with the combined occurrence of all three groups. PA/SI data show SVOCs occurring at a relatively low 28% of sites with a relatively frequent occurrence of single contaminant groups, while sites with RODs show SVOCs occur 73% of the time with a high incidence of all three groups together. It is uncertain whether these differences occur because site characteristics are actually different or because the site characterization processes are different. The differences may be explained, in part, by the fact

Exhibit 3-5: Frequency of Volatile Organic Compounds, Semi-Volatile Organic Compounds, and Metals at NPL Sites Without RODs[a]



Notes:

[a] Includes 517 National Priorities List sites without Records of Decision. Contaminant information is not available for 6 sites. Each site is counted only once.

[b] Includes 18 sites that contain only explosives, radon, nitrates, or other inorganics.

Source: U.S. EPA, Technology Innovation Office, site assessment data, 1992.

that most of the PA/SI data reported under the original site scoring process are associated with ground water impacts. More SVOCs are likely to be found during the RI/FS, when a more thorough investigation of soil and sediments is conducted. However, it is also possible that because of EPA's policy of cleaning up the worst Superfund sites first, the NPL sites with RODs signed prior to fiscal year 1991 actually are different from the remaining sites and contain more complex wastes.

Considering the overall higher values of the ROD data, EPA believes that the PA/SI data indicate the *minimum* overall occurrence of contaminants that need to be remediated. The RI/FS data will indicate a greater frequency of these contaminant groups. However, for a specific site, the RI/FS data may indicate that some contaminants identified in the PA/SI will not require remediation.

3.4.3.2 Subgroups of Volatile and Semi-Volatile Organics

Volatile organic chemicals (VOCs) and SVOCs are subdivided into more specific treatability subgroups that better coincide with the application of certain technologies, such as bioremediation. The PA/SI data were collected to conduct a more detailed analysis of the following contaminant subgroups:

- VOC subgroups: chlorinated; BTEX (benzene, toluene, ethylbenzene, xylene); and other nonchlorinated (ketones and alcohols). Chlorinated VOCs, widely used as solvents, are the most prevalent class of organics, present at 223 (43%) of NPL sites without RODs. Because listing sites on the NPL that are contaminated with petroleum products alone is prohibited under CERCLA, it is reasonable to assume that contaminants other than BTEX were present and contributed to site listing.

- SVOCs subgroups: polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), pesticides, phenols (including pentachlorophenol), and other SVOCs, which includes chlorobenzene and phthalates. PCBs, the most common SVOC, are present at 61 sites. Pesticides are found at 50 sites, PAHs at only 24 sites, and phenols at 22 sites.

Exhibit 3-6 shows the frequency of occurrence of these subgroups at the 523 NPL sites. Each subgroup was counted only once per site, regardless of whether it occurred alone, with other types of contaminants, or in more than one matrix. Because more than one contaminant subgroup can be present at a site, the total number of occurrences is greater than the total number of sites.

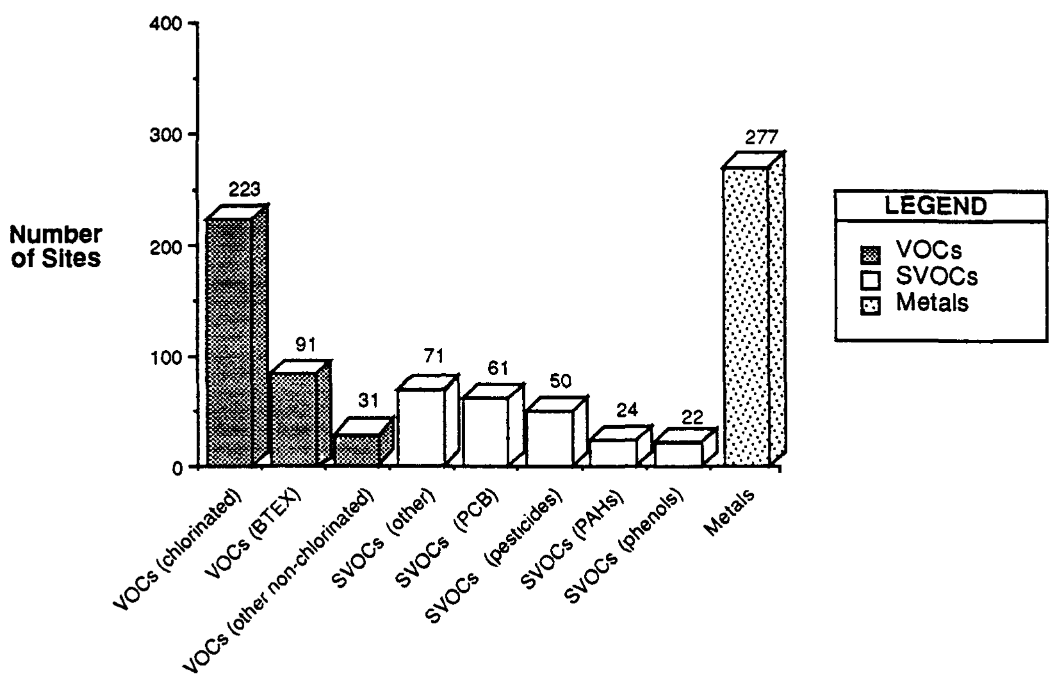
3.4.3.3 Most Common Individual Contaminants

Exhibit 3-7 shows the 11 contaminants that occur most frequently at the NPL sites without RODs. Of the 11 constituents, six are VOCs, four are metals, and only one is a SVOC. (As noted for previous analyses, a contaminant is counted no more than once for each site and more than one contaminant can occur per site). A similar analysis conducted for sites *with* RODs reveals the same 11 contaminants.

3.4.4 Estimated Quantities of Contaminated Material

The market also can be described in terms of the quantity of contaminated material to be remediated. Estimates of quantities of contaminated material at sites without RODs (for which an RI/FS has not been completed) were developed by using data from

Exhibit 3-6: Frequency of Contaminant Subgroups Present in All Matrices at NPL Sites Without RODs[a]

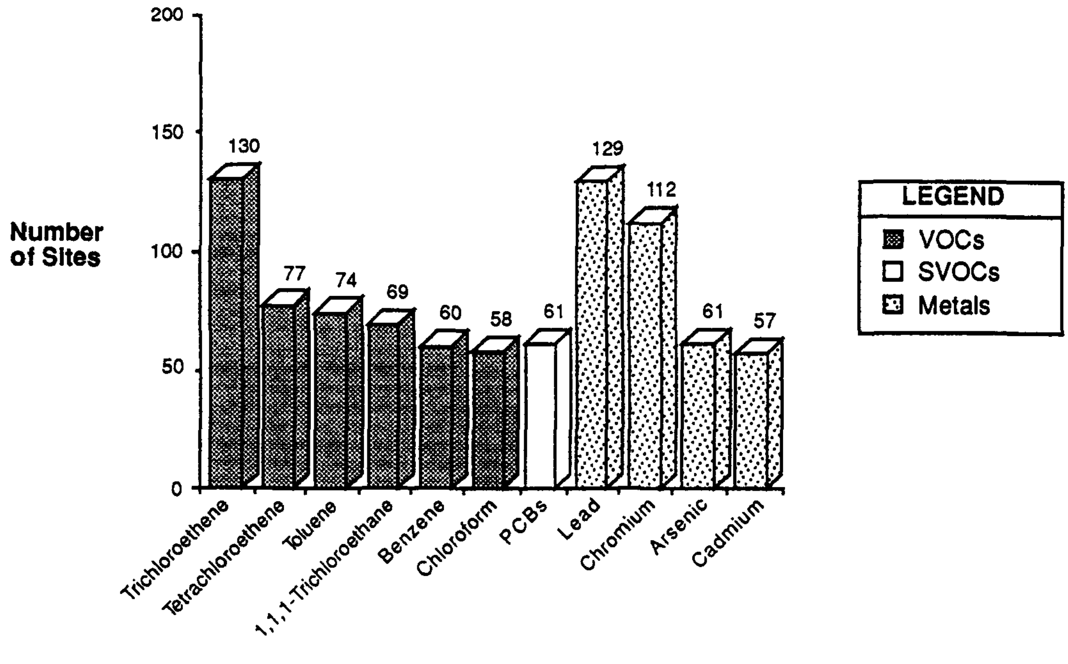


Notes:

[a] Includes 517 out of 523 National Priorities List sites without Records of Decision. Contaminant information at 18 of these sites do not fall into these subgroups and site assessment information is not available for 6 sites. A site may contain one or more of the nine contaminant subgroups.

Source: U.S. EPA, Technology Innovation Office, site assessment data, 1992.

Exhibit 3-7: Frequency of the Most Common Contaminants in All Matrices at NPL Sites Without RODs



Notes:
[a] Includes 517 out of 523 National Priorities List sites without Records of Decision. Contaminant information at is not available for 6 sites. There may be one or more of these contaminants at each site.

Source: U.S. EPA, Technology Innovation Office, site assessment data, 1992.

sites with RODs. Information on the quantities of soil, sludge, or sediment to be remediated by treatment, containment, or off-site disposal is available for 310 sites of the 712 sites with RODs. The data from these 310 sites are used to estimate and characterize the quantities of material requiring some type of remediation. Statistical outliers in the data were eliminated. The resulting characterization is described below.

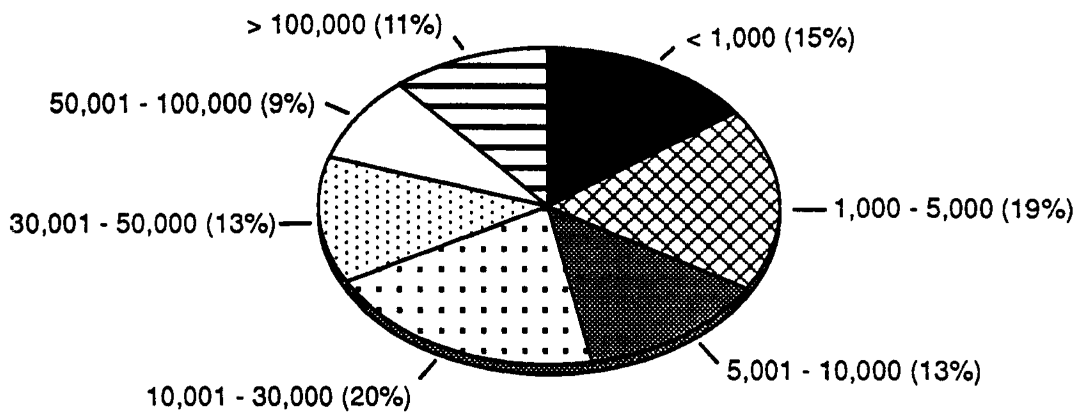
3.4.4.1 Distribution of Quantities

The distribution of the total quantities per site of contaminated soil, sediment, and sludge requiring remediation are presented in Exhibit 3-8. Based on these estimates, approximately one-half of the 310 sites contain less than 10,000 cubic yards, 20% contain 10,000 to 30,000 cubic yards, and only 11% of the sites contain over 100,000 cubic yards of contaminated material. These data indicate an appreciable market for technologies that can effectively treat small quantities of contaminated media. However, reviews of RODs indicate that quantities of waste to be capped often are not documented in the ROD. Therefore, the proportion of sites that contain large quantities of wastes may be greater than the data demonstrate. The quantity distributions for soil, sediment, and sludge shown in Appendix A, Exhibit A-4, indicate that almost 75% of the data are for contaminated soil.

3.4.4.2 Quantities by Major Contaminant Group

Estimates of the quantities of contaminated soil, sediment, and sludge at the 523 sites without RODs can be calculated for the three contaminant groups. These values are derived by multiplying the average quantities for the 310 sites with RODs by the number of NPL sites without RODs that contain those contaminant groups (from Exhibit 3-5).

Exhibit 3-8: Distribution of Total Quantities of Contaminated Soil, Sediment, and Sludge at Selected NPL Sites With RODs (Estimated Cubic Yards)



Note: Data are derived from 342 Records of Decision for 310 National Priorities List sites. Quantities are for material to be remediated by treatment, containment, and disposal. Quantity data for the other 402 sites that have RODs are not available.

Source: U.S. EPA, RODs, fiscal years 1982-1991.

The results of the calculations are shown in Appendix A, Exhibit A-5. It was assumed that all of the contaminated material at a site contained the contaminant groups present. The average site quantities by contaminant group varied from a low of 13,700 cubic yards for VOCs alone to a high of 102,400 cubic yards for VOCs, SVOCs, and metals found together. Statistical outliers were not included in the calculations.

Total quantities are shown in Exhibit 3-9. The values are estimates of the *total* amount of contaminated material present that will be remediated by being either treated or disposed.

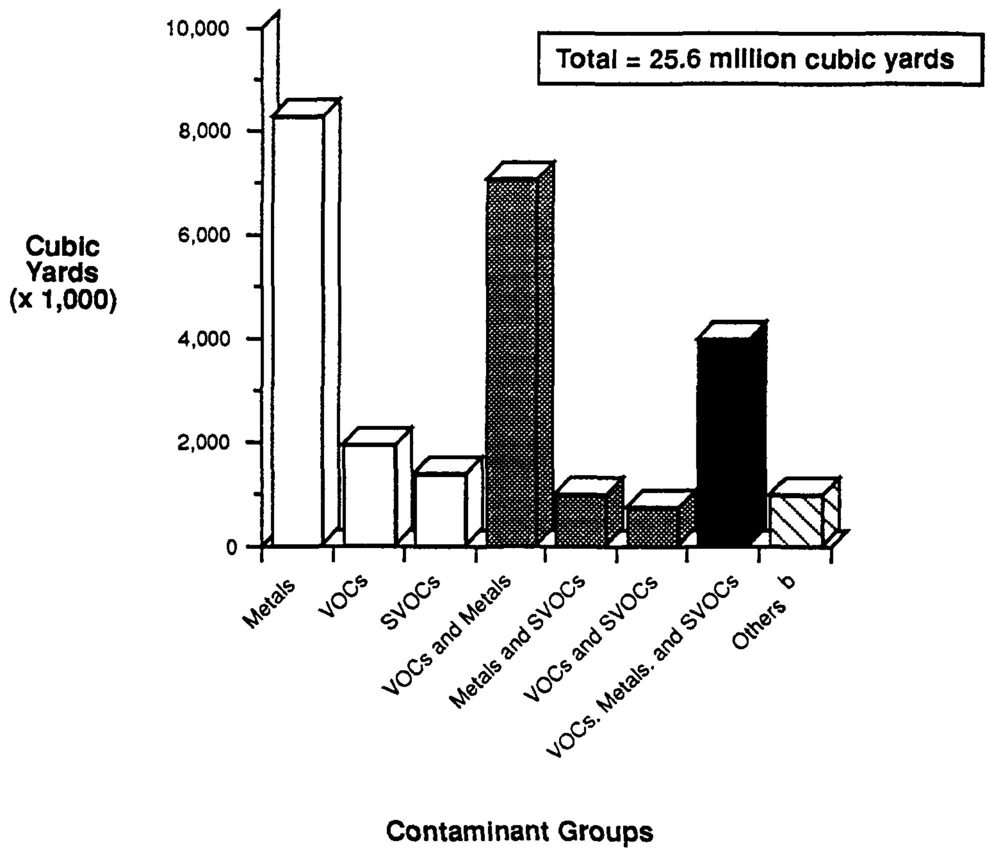
Approximately 25.6 million cubic yards of soil, sludge, and sediment are to be remediated at the 523 sites without RODs. Metals, alone and in combination with other contaminants, account for 20.5 million cubic yards. VOCs, alone and combined with other contaminants, total 13.9 million cubic yards; and SVOCs total 7.25 million cubic yards. The overall quantities for material contaminated with metals, VOCs, and SVOCs are directly proportional to their frequency of occurrence (Exhibit 3-5).

3.4.4.3 Quantities by Contaminant Source

The quantity data also were sorted according to the 10 most common industrial sources of contamination (Exhibit 3-10). Three of the top four, and four of the top six sources generate waste containing metals or solvents.

The average waste quantity for each source of contamination was estimated by using the entire quantity of waste at each corresponding site. If a site had more than one source, the quantity was counted again for each source. Therefore, the totals are not additive. Total and average quantities by each source of contamination are calculated, then the averages are multiplied by the number of NPL sites without RODs for each source category. The average quantities for each site source, shown in Appendix A, Exhibit A-6, ranged from a low of 26,500 cubic yards for electronic/electrical equipment manufacturing to a high of 578,400 cubic yards for fabricated metal products manufacturing sites. The highest estimated total quantities are for primary metal products manufacturing (primarily ore processing facilities), followed by metal plating and agricultural production and services.

Exhibit 3-9: Estimated Quantity of Contaminated Soil, Sediment, and Sludge By Major Contaminant Groups at NPL Sites Without RODs[a]



Notes:
[a] Includes 517 out of 523 National Priorities List sites without Records of Decision. Contaminant information is not available for 6 sites. A site is counted only once. Site-specific data are not available for quantities of material to be remediated at sites without RODs. These values are derived from ROD estimates for sites containing similar contaminants (see Appendix A, Table A-6 for supporting calculations).
[b] Includes 18 sites that contain only explosives, radon, nitrates, or other organics.

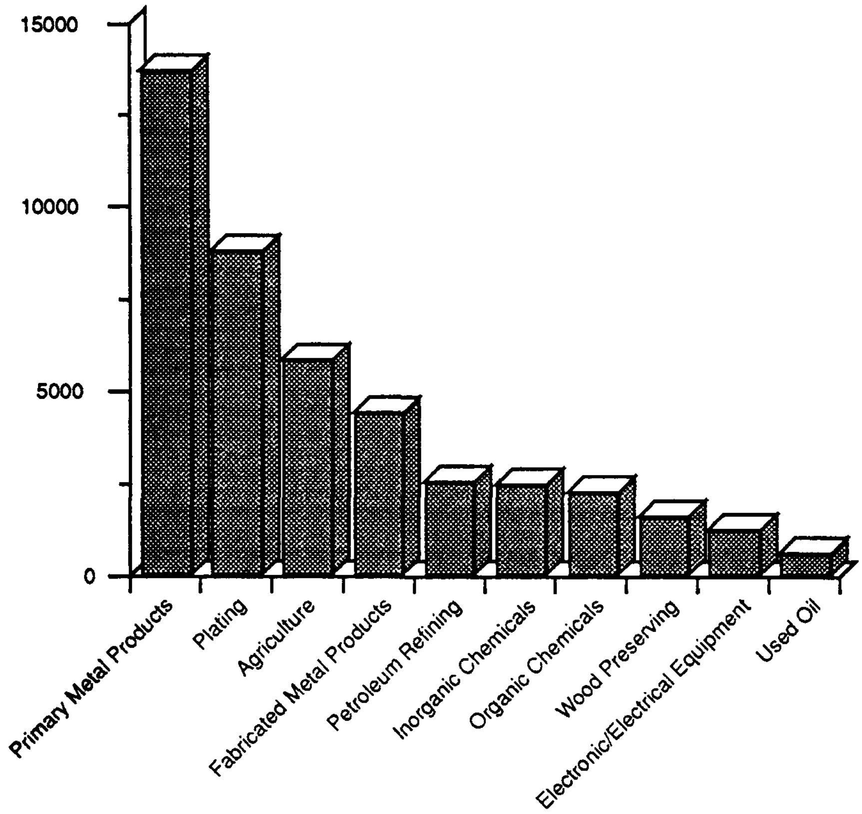
Source: U.S. EPA, Technology Innovation Office, assessment data, 1992.

3.5 Intermediate-Term Demand for Remedial Technologies

The potential intermediate-term market for specific treatment technologies can be projected from the study of site contaminants above and the trends in technology selection discussed in Chapter 2. This analysis primarily considers contaminants present at a site, and does not explicitly incorporate other site characteristics that also affect technology selection. Although these observations are supported by current technology trends, further experience with these technologies and the development of new methods (such as those in the Superfund Innovative Technology Evaluation [SITE] program) also will affect the types of remedies selected. Given these considerations, the data indicate the following projections for the potential markets for certain treatment technologies:

- In the past several years, there has been a slight decrease in the proportion of sites for which incineration has been selected, and in 1991, the selection of on-site incineration dropped

Exhibit 3-10: Estimated Quantity of Contaminated Soil, Sediment, and Sludge By Sources of Contamination at NPL Sites Without RODs[a,b]



Notes:

[a] Site-specific data are not available for quantities of material to be remediated at sites without Records of Decision (ROD). These values are derived from ROD estimates for sites with similar sources of contamination. Quantities are not totaled because some sites have more than one source.

[b] Includes 449 out of 523 National Priorities List sites without RODs. Source of contaminant information is not available for 74 sites. Some sites have been counted more than once (see Appendix A, Table A-5 for supporting calculations).

Source: U.S. EPA, Technology Innovation Office, site assessment data, 1992.
U.S. EPA, RODs, fiscal years 1982-1991.

sharply. Also, SVOCs, the most likely candidates for incineration, do not occur frequently at intermediate-demand sites. These factors may lead to an overall decrease in the use of incineration at Superfund sites. However, because of its broad application to organic contaminants and its ability to meet stringent cleanup levels, incineration will probably continue to play a role in future Superfund cleanups. While off-site incineration is likely to continue to be used to treat small quantities of concentrated waste, including residuals of separation technologies, the future use of on-site incineration is uncertain.

- The selection of solidification/stabilization, which accounts for about 25% of treatment technologies, has been steady. This technology is the most common treatment for metals, which occur at 277 intermediate-demand sites. These data indicate a considerable market for solidification/stabilization. Concerns over its long-term effectiveness may lead to the development of innovative alternatives to this technology.

- The selection of SVE, chosen 83 times at NPL sites, has expanded in recent years. SVE is the most frequently chosen technology for both chlorinated and nonchlorinated VOCs in soil.

VOCs occur at a minimum of 318 intermediate-term NPL sites, and in at least 14 million cubic yards of contaminated material. In addition to the use of SVE for contaminant removal, at least 91 of the sites containing BTEX offer an opportunity to augment SVE with bioventing. SVE also can operate in the presence of metals: the 107 sites that have VOCs and metals in 7 million cubic yards of material may use SVE for pretreatment. Based on these data, the use of SVE is likely to continue at its high level, and may even increase. In addition, further development of this technology, and potentially bioventing for SVOCs, is expected to expand the application of SVE to sites not now amenable to this technology.

- Bioremediation has been selected for NPL sites 45 times, and for the past several years its use has not increased. Historically, the primary demand for bioremediation (land treatment, slurry phase, and some types of *in situ* treatment) has been for PAHs, phenols, and nonchlorinated VOCs, primarily BTEX. PAHs were identified at only 24 sites, phenols at 22 sites, and BTEX at 91 sites. These data indicate that the previously-selected forms of bioremediation at NPL sites are not likely to increase above current levels. However, several developments may lead to growth in the use of biotreatment: extensive research into bioremediation to increase the range of its application; the use of air-based aeration methods (bioventing and air sparging); and additional future listings of wood preserving sites on the NPL.

- Thermal desorption has been chosen a total of 27 times, and its selection is increasing. It has been selected primarily to treat PCBs and VOCs, alone or in the presence of metals. VOCs are present at a minimum of 318 intermediate-term sites containing 14 million cubic yards of material. VOCs with metals are present in 7.2 million cubic yards of material at 107 of these sites. PCBs are found at 61 sites. Based on these data, the use of thermal desorption may increase for these applications.

- PCBs are also the primary niche for solvent extraction (selected six times) and chemical dechlorination (selected seven times). These technologies may apply to some of the 61 PCB sites to treat soil, or in the case of dechlorination, liquid residuals of thermal desorption or solvent extraction. However, limited experience with these technologies makes it difficult to predict the extent of future applications, particularly for contaminated soils.

- Soil washing also has been selected for treatment of PAHs and pesticides, but its greatest future niche may be to treat metals, which occur in over 20 million cubic yards of material at a minimum of 277 intermediate-term sites. Soil washing has been chosen to treat all of the most frequently found metals: lead, chromium, arsenic, and cadmium.

- *In situ* flushing has been selected at a total of 17 sites to treat VOCs (11 sites) and SVOCs (six sites). This technology may be selected for these groups of contaminants if other technologies prove impractical, such as at landfills, and when site conditions allow recovery of flushed contaminants.

- Innovative technologies have been selected to address metals at only 20 sites, even though metals occur frequently and in large quantities at NPL sites. This represents an opportunity to develop methods to separate and, perhaps, recycle metals, as an alternative to solidification/stabilization.

- Lastly, another large market exists for the treatment of ground water in place, to achieve the desired cleanup goals that in many cases cannot be achieved by pump-and-treat technology alone.

3.6 Estimated EPA Cleanup Costs

EPA has not estimated the total public and private costs of remediating current and future NPL sites. EPA has estimated the Agency's future cost, known as the "Trust Fund liability," to complete the cleanup of sites currently on the NPL. For fiscal year 1994 and beyond, the estimate is $16.5 billion for all costs incurred by EPA for work from PA through RA and operation and maintenance. This cost includes direct and indirect site activities, oversight of PRP activities, and program support. For fiscal year 1993, Congress allocated $1.6 billion.

The estimate of future EPA costs does not include cleanup of the 400-800 sites anticipated to be added to the NPL in the future. Nor does it include costs incurred by PRPs, other federal agencies, or states. EPA will be responsible for starting only about 35% of all new RI/FSs, and about 25% of RAs. PRPs will be responsible for most RI/FS and RA costs for NPL sites. Because it is not known whether PRP-lead cleanups are more or less expensive than fund-lead, projecting the value of this market is difficult.

Based on an analysis of fiscal year 1991 RODs, EPA estimates that the average cost of conducting a site cleanup is $27 million. The average cost for EPA to conduct one RA is $13.2 million, and the historical average number of RAs per site is 1.8. The average RA cost includes work conducted by the cleanup contractors, oversight by EPA, and initial operation and maintenance costs.

3.7 Marketing Considerations

Although the overall market for remediation services at about 2,000 NPL sites has been fairly well described, the specific technologies to be applied at each site have not been determined. The technology decisions will be based on the information available, and there are two points in the decision-making process at which information on new technologies is critical: during remedy selection, and during remedy design and procurement. Thus, technology vendors must be aware of the information sources as well as how site managers consider their options during these two cleanup phases.

3.7.1 Market Considerations During Remedy Selection

The Superfund RI/FS process is an integrated, phased approach to characterizing the site risks and evaluating remedial alternatives. In developing and screening remedial alternatives, technologies are initially identified and screened based on three criteria: technical implementability, effectiveness, and relative cost. It is often at this early stage of the RI/FS that a particular technology is included or excluded from further consideration. EPA uses a variety of information sources to identify potential technologies, including innovative ones. Following the identification and screening of alternatives, a detailed comparative evaluation is conducted, using the nine evaluation criteria specified in the National Contingency Plan. Information on technology performance and cost is important during this phase. Since this type of information is often lacking for innovative technologies, treatability studies or on-site demonstrations are beneficial for assessing cost and performance.

Engineering consulting firms generally conduct the RI/FSs for EPA, states, and responsible parties. The familiarity of a consulting engineer with a specific technology may impact whether the technology is considered, and the weight placed on that technology during the screening process. At this time, EPA contracts under the Alternative Remedial Contracting Strategy (ARCS) to conduct RI/FSs. A current list of regional service contracts is provided in Appendix B. EPA is scheduled to award new remedial contracts in 1994 under the Remedial Action Contracting Strategy (RACS).

While Superfund policies encourage the selection and implementation of new technologies, the Superfund remedy selection process can present some hurdles for innovative technology vendors:

- Because Superfund site managers may not have as much information on the performance and cost of an innovative technology as for a conventional method, there is a bias toward the selection of conventional treatment technologies. In the development and screening of alternatives, EPA often relies on readily available technology information sources. The Agency has made significant progress developing systems for disseminating information about remedial technologies. Nonetheless, Superfund site managers may have difficulty comparing the merits of an innovative and a conventional technology if they do not have information on a technology's cost; implementability; short- and long-term effectiveness; and ability to reduce the toxicity, volume, or mobility of the contaminants. The National Contingency Plan (NCP) and EPA policy encourage the use of bench- or pilot-scale treatability studies, when appropriate and practical. EPA policy also stipulates that innovative technologies cannot be eliminated from consideration solely on the grounds that an absence of full-scale experience or treatability study data makes their performance and cost less certain than other forms of remediation.[10]

- For sites where no responsible party is involved, the remedial design contractor at a site is prohibited from conducting the remedial action for that site. The EPA has determined that there may be a conflict in permitting the same contractor to conduct both activities. A technology vendor that also provides RI/FS services should determine the relative value of the two opportunities before deciding which service to provide.

In general, technology vendors should participate, whenever possible, in the programs cited in Section 3.7.3. They also may consider using Appendix A, Exhibit A-3 to identify the individual sites appropriate for their technologies and provide information on the technologies' capabilities to the respective site manager or Regional Office (Appendix B). Such actions may lead to more comprehensive consideration of the technologies at a given site. This approach requires vendors to identify the site early in the RI/FS process, so that there is time to conduct any necessary treatability studies (note that the contaminants listed in Appendix A, Exhibit A-3 are those identified during PA/SIs, and later site analyses may show that they do not require remediation or may identify additional contaminants in need of cleanup).

3.7.2 Market Considerations During Design and Procurement

Once a remedy has been selected and documented in a ROD, the project enters the design process, where the details of the cleanup, such as waste quantities and performance standards, are more clearly specified. At this stage, federal and state agencies need technology information for preparing requests for proposals and evaluating bids.

When EPA is responsible for the cleanup of a Superfund site, it uses one of the following funding mechanisms:

- Alternative Remedial Contracting Strategy (ARCS—soon to be known as Remedial Action Contracting Strategy [RACS])—EPA contracts with architecture/engineering (A/E) firms for the remedial program.

- Emergency Remedial Contracting Strategy (ERCS)—EPA contracts with A/E firms for the removal program.

- Interagency Agreements (IAGs)—EPA enters into agreements with the U.S. Army Corps of Engineers or Bureau of Reclamation.

- Cooperative Agreements (CAs)—EPA enters into agreements with states, political subdivisions, or Indian Tribes.

More detailed information on contracting and subcontracting to the Superfund program can be found in a guide published by EPA.[11]

The two most definitive sources of information on selected remedies for sites entering RD and RA are the ROD, the *ROD Annual Report*,[6] and the *Innovative Technologies: Semi-Annual Status Report*.[2] The ROD provides detailed information on the site contaminants and risks posed, the selected remedy, estimated costs, and associated performance standards. The Semi-Annual Report provides more current information on sites using innovative technologies. It includes information on contaminants and media requiring remediation, anticipated or actual cleanup timelines, and expected site lead (EPA, state, private party) for these sites.

A vendor may use these publications to identify opportunities. Vendors may want to contact the EPA or state site manager and the anticipated site remedial design firm or agency. Such contact helps the regional site manager become familiar with the capabilities (*e.g.*, cost, performance, availability) and demonstrated performance of the technologies. Vendors also may provide background information to site managers to support the development of the final design specifications. Keeping abreast of site activities allows vendors to be responsive to requests for proposals (RFPs) for the site remedial action. Once an RFP has been issued, the award of a contract may take several weeks to six months.

3.7.3 Research and Development

EPA established the Superfund Innovative Technology Evaluation (SITE) program as its primary mechanism for promoting the development of new technologies. EPA has budgeted over $14 million for the SITE program in fiscal year 1993. SITE is administered by EPA's Office of Research and Development (ORD) to evaluate field-ready and emerging innovative technologies offered by specific companies. EPA selects participants through a solicitation and evaluation of proposals.

Two major components of the SITE program are the Demonstration Program and the Emerging Technology Program. The Demonstration Program develops reliable engineering, performance and cost data on innovative technologies by demonstrating them at hazardous waste sites or under conditions that simulate actual hazardous waste and site conditions. Ninety-three technologies are currently being demonstrated in the Program, and to date 48 of these technologies have completed demonstrations. Almost 40% of SITE Demonstration technologies are physical/chemical methods, 17% are biological, and 17% are thermal desorption techniques. The others are innovative technologies for thermal destruction, solidification/stabilization, materials handling, or radioactive waste treatment.

The Emerging Technology Program assists technology development at the bench and pilot scale. EPA has provided technical and financial support for 53 projects in the Emerging Technology Program. Of these projects, 20 have been completed. About half of the projects are physical/chemical treatment methods, 25% are biological treatment, and 15% are thermal destruction. The remaining are either materials handling and solidification/stabilization.

3.7.4 Disseminating Innovative Technology Information

Information on an innovative technology or a technology vendor must be readily available if a technology is to be considered as a potential remedy at a hazardous waste site. Those developing lists of cleanup alternatives and federal and state staff preparing bid documents often refer to the many sources of technical information available on innovative and established treatment technologies. Listed below are some of the primary resources and the ways that technology developers and vendors may use them to publicize their capabilities:

- Vendor Information System on Innovative Treatment Technologies (VISITT). This diskette-based database was released in June 1992 by the EPA's Technology Innovation Office (TIO), and is updated annually. It contains vendor-supplied information on innovative treatment for ground water *in situ*, soil, sludge, sediment, and solid-matrix waste, including applicable contaminants and matrices, summary performance data, and project-specific information. Users can screen technologies for specific site and waste applications. Orders for VISITT may be faxed to EPA's National Center for Environmental Publications and Information (NCEPI) at 513-891-6685 (specify diskette size). Information on how to be included in VISITT is available from the VISITT Hotline at 800-245-4505.

- Alternative Treatment Technology Information Center (ATTIC). This online computer resource is maintained by EPA's Office of Research and Development (ORD), and consists of several databases pertaining to remedial treatment technologies. The ATTIC database contains more than 2,000 abstracts of papers, journal articles, and technical documents concerning both available and innovative treatment technologies. These abstracts can be screened to identify applicable technologies and data. To access ATTIC on-line using a personal computer, call 301-670-3808.

- Those conducting RI/FSs often use reports on completed SITE program evaluations and expertise offered by ORD staff on specific technologies. A list of projects, available reports, and project managers who offer technical assistance to technology users may be found in the SITE Program Profiles available from ORD Publications at 513-569-7562.[12] Information on how to participate in the SITE program is available from the Risk Reduction Engineering Laboratory's Site Demonstration and Evaluation Branch at 513-569-7696.

- Technical Guidance. ORD also develops guidance on specific types of innovative technologies. Most recent guidance is contained in eight to 10 page engineering bulletins that describe the technology status, applications, performance, and cost, and identify knowledgeable EPA contacts. ORD also has developed guidance on evaluating and remediating specific types of contaminants or sites. A list of these and other EPA technical guidance is found in *Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site*

Remediation (may be ordered by fax from NCEPI at 513-891-6685).[13]

In addition, becoming a member of various professional societies and trade groups may help a vendor promote specific capabilities.

3.8 Conclusions

Last year, 30% of the RODs for NPL sites incorporated at least one innovative technology (primarily for source control) and 42% of all treatment processes for source control selected between 1982 and 1991 have been innovative. In the future, Superfund sites will continue to offer important opportunities for established and innovative technologies. In particular, innovative technologies are needed for soil and other wastes, and for ground water, especially *in situ*. Although Superfund sites comprise a relatively small portion of the total inventory of contaminated sites to be addressed by all site cleanup programs, these sites represent a relatively well-defined market for the next eight years. Furthermore, Agency policy encourages the consideration and selection of innovative treatment to remediate NPL sites. The estimated cost that EPA will incur to complete the cleanup of sites currently on the NPL is $16.5 billion. Because much of the additional cleanup will be accomplished by PRPs, the total market value is much higher.

The analysis of site contaminants, sources, and quantities provides valuable information to guide business decisions concerning technology development and investment. In particular, the data indicate that in the next three to eight years there will be a large demand for remediation of metals (an estimated 20.5 million cubic yards) and VOCs (13.9 million cubic yards). For known innovative technologies, the largest potential market appears to be for SVE. Thermal desorption and soil washing also have a potential for greater use. The market for bioremediation may expand because of new developments. Also, the demand for solvent extraction and dechlorination is less clear because there is less experience with these technologies.

Although the selection of innovative technologies has been increasing in recent years, this growth has been impeded by a lack of readily available performance and cost data and a lack of familiarity by site managers. Technology vendors can help overcome these difficulties by disseminating information about the performance and cost of specific technologies to central information sources (*e.g.*, VISITT and ATTIC) commonly used by remediation professionals and state and federal officials. Vendors also may consider supplying appropriate information directly to site managers and consulting engineers who are evaluating or designing remedies. These activities will help to ensure that the most current data are readily available.

3.9 References

1. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Final Rule, National Priorities List for Uncontrolled Hazardous Waste Sites," 57 *Federal Register*, pg. 47180, October 14, 1992.

2. U.S Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "Innovative Treatment Technologies: Semi-Annual Status Report," EPA/540/R-92/011, October 1992.

3. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "CERCLA Information System (CERCLIS)," 1992.

4. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "National Priorities List Sites: 1991."

5. U.S. Environmental Protection Agency, Office Emergency and Remedial Response, "Record of Decision Information System," 1992.

6. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "ROD Annual Report Fiscal Year 1991," PB92-963359, April 1992.

7. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Superfund NPL Characterization Project: National Results," EPA/540/8-91/069, November 1991.

8. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Fourth Quarter FY 92 Superfund Management Report," December 1992.

9. U.S. Environmental Protection Agency, "Analysis of Revisions to the Hazard Ranking System," Presentation by Suzanne Wells at the Air & Waste Management Association, 85th Annual Meeting and Exhibition, Kansas City, Missouri, June 1992.

10. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Furthering the Use of Innovative Treatment Technologies in OSWER Programs," OSWER Directive 9380.0-17, June 10, 1991.

11. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Contracting and Subcontracting Guide to the Superfund Program," Publication 9200.5-402A, NTIS No. PB92-963274, May 1992.

12. U.S. Environmental Protection Agency, Office of Research and Development, "The Superfund Technology Innovation Evaluation Program: Technology Profiles," Fifth Edition, EPA/540/R-92/077, December 1992.

13. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation (A Bibliography of Information Sources)," EPA/542/B-93/001, January 1993.

CHAPTER 4
DEMAND FOR REMEDIATION OF RCRA CORRECTIVE ACTION SITES

This chapter describes factors affecting the demand for cleanup services at hazardous waste treatment, storage, and disposal facilities (TSDFs) regulated under the Resource Conservation and Recovery Act (RCRA). Most TSDFs are operating industrial facilities or are in the process of closing. RCRA requires that these facilities remediate releases of hazardous wastes and their constituents. This chapter describes the process for cleaning up these facilities and the number of such facilities. Site owners or operators are responsible for necessary remedial action with oversight by EPA or one of the 16 states[a] authorized to implement RCRA corrective action requirements. Treatment, storage, and disposal facilities regulated under RCRA (as amended) represent a substantial market for cleanup technologies.

RCRA sets forth comprehensive national requirements for managing the treatment, storage, disposal, and recycling of solid and hazardous waste. Several regulatory programs exist under RCRA, but the largest is the "Subtitle C" program, which among other provisions, establishes a system to control hazardous waste from generation through ultimate disposal ("cradle-to-grave"). Facilities that manage hazardous waste are called RCRA treatment, storage, or disposal facilities (TSDFs). EPA's Office of Solid Waste (OSW) implements the RCRA Subtitle C hazardous waste management and corrective action programs.

The 1984 Hazardous and Solid Waste Amendments (HSWA) expanded the scope of RCRA to include requirements to reduce the risk to human health and the environment posed by releases from historic areas of waste management at TSDFs. EPA established the RCRA corrective action program to remediate releases from old solid waste management units (SWMUs) at TSDFs. EPA defines a SWMU as "any discernable unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include areas at a facility at which solid wastes have been routinely and systematically released."[1]

Many of the facility types and waste types in the RCRA corrective action universe are similar to those found in the Superfund program. The process for evaluating and cleaning up sites also is similar. However, unlike the Superfund program, there is no central fund to begin or complete the cleanup of RCRA facilities. Cleanups are funded by the site owners or operators.

4.1 Program Description

The overall strategy for the RCRA corrective action program is defined in the 1990 RCRA Implementation Study (RIS).[2] The RIS encourages the corrective action program to produce the greatest near-term environmental benefits. Two key components of this strategy are to: (a) set national priorities to direct resources to the highest priority facilities; and (b) increase emphasis on near-term actions to reduce imminent threats and prevent the further spread of contamination. The emphasis on near-term actions is a significant change in program emphasis and is expected to result in increased field cleanup activity over the next eight years.

4.1.1 Corrective Action Process

The corrective action process is outlined in the proposed Corrective Action Rule, published on July 27, 1990.[1] The fiscal year 1992 and fiscal year 1993 RCRA Implementation Plans (RIPs) and the RCRA Stabilization Strategy (1992) provide

[a] Arizona, Arkansas, California, Colorado, Georgia, Idaho, Illinois, Minnesota, Nevada, New York, North Carolina, North Dakota, South Dakota, Texas, Utah, and Wisconsin; EPA has work-sharing arrangements with additional states.

additional guidance for the RCRA corrective action program.[3][4][5] In fiscal year 1992 the National Corrective Action Priority Ranking System (NCAPS) was established to rank the relative risks that corrective action sites pose to human health and the environment. Through the use of NCAPS, EPA focuses resources for the corrective action program on high-priority facilities. The fiscal year 1993 RIP encourages the use of innovative treatment technologies by increasing the priority of facilities at which these technologies are under consideration.

The fiscal year 1992 RCRA Stabilization Strategy established procedures for evaluating the need for, and implementing near-term stabilization actions.[5] Stabilization actions for RCRA hazardous waste are similar to those undertaken in Superfund emergency response actions, but place much greater emphasis on substantial action to prevent the further spread of contamination. EPA's emphasis on stabilization activities in the past year has increased the pace of RCRA corrective actions. In some cases, this has allowed an extended schedule for final cleanup.

The proposed Corrective Action Rule would create a new "Subpart S" in the RCRA Part 264 regulations to specify requirements for conducting corrective action at TSDFs. The corrective action process, as specified in the proposed rule, contains a series of four steps similar to those found in the Superfund program. These steps, as modified by the stabilization guidance, are listed below:

1) EPA or an EPA-authorized state conducts an initial assessment, termed a "RCRA Facility Assessment" (RFA) of the facility. The RFA involves identification and examination of a facility's solid waste management units (SWMUs) to determine if a release has occurred or if the potential for a release exists.

2) If the RFA reveals a release, the owner or operator of the facility may be required to conduct a "RCRA Facility Investigation" (RFI), which involves sampling and other efforts to determine the nature and extent of contamination and to fully characterize site geological and hydrological conditions. If the release poses a sufficient threat, the owner or operator may be required to take near-term action (such as stabilization) to contain or remediate the contamination.

3) If the regulatory agency determines from the RFI that corrective action is needed, the owner or operator is then responsible for performing a "Corrective Measures Study" (CMS) to identify alternative measures to remediate the contaminated areas. Near-term action also may be required after the RFI.

4) Upon approval of a cleanup plan by the regulatory agency, the owner or operator may begin "Corrective Measures Implementation" (CMI), which includes designing, constructing, maintaining, and monitoring the remedial measures. A CMI is conducted by the owner or operator with regulatory agency oversight.

4.1.2 Corrective Action Implementation

Corrective action can be implemented either through the permit process or enforcement orders. RCRA permits are required for all facilities that treat, store,[b] or dispose of hazardous waste. HSWA requires that all hazardous waste facilities that obtain a RCRA permit after November 8, 1984, take corrective action for any releases from past disposal or recent contamination at or from the facility, including all units (or areas) and off-site releases. In addition, TSDFs operating under interim status, rather than a RCRA permit, may be required to take corrective action under an enforcement order or state order in an authorized state.

States may seek EPA authorization to manage, with EPA oversight, the hazardous waste and corrective action programs. To date, 46 states, some territories, and the District of Columbia are authorized to manage their own hazardous waste programs, only 16 of which are authorized to implement the corrective action provisions of RCRA.[c] In addition

[b] For over 90 days, unless conditionally exempted.

[c] The following states and territories are *not* authorized under the RCRA base program to manage RCRA hazardous waste: Alaska, Hawaii, Iowa, Wyoming, Puerto Rico, Trust Territories, the Virgin Islands, and American Samoa.

to RCRA corrective action, many states also have their own cleanup programs under their respective ground-water programs. In either case, a state may adopt regulations that are more stringent than the federal regulations. Under RCRA §3011, EPA Regions also have developed grants and cooperative agreements, which may give the states the lead for corrective action oversight prior to full authorization.

4.2 Factors Affecting Demand for Cleanup

Statutory, regulatory, and programmatic changes to the RCRA program may affect the demand for RCRA site cleanup technologies. Specifically, the following factors may impact this demand:

- Many of the current standards for land disposal restrictions (LDRs) for contaminated soils can be met only through the use of incineration. However, a site-specific treatability variance for contaminated soils can be used for RCRA corrective actions and closures, and CERCLA response actions.[6]

- There continues to be widespread interest in making changes to the law. Over 150 bills concerning RCRA have been submitted in Congress over the last two sessions. Any future changes to RCRA could impact the size and characteristics of the regulated universe of facilities or wastes.

- The definition of "RCRA hazardous waste" is currently under revision. Changes in the definition may affect the number of facilities and types of wastes subject to RCRA requirements.

- The Corrective Action Management Unit (CAMU) Final Rule, which became effective in April 1993, provides flexibility with respect to LDRs and minimum technology requirements for remedial waste management at RCRA sites. This rule should facilitate the use of treatment technologies at RCRA corrective action sites.

4.3 Number and Characteristics of Facilities

Currently, EPA tracks the cleanup progress at facilities where corrective action has begun, and limited information on the number of these facilities is presented here. Although specific data on the universe of corrective action sites are not yet available, data on TSDFs, in general, can indicate the potential extent of corrective action in the future. Most of the information presented in this section is based on the total universe of TSDFs subject to corrective action requirements, but which may or may not actually require corrective action. More accurate estimates of the number and scope of RCRA corrective action and the specific hazardous constituents to be addressed are being developed by OSW and should be available to the public in 1994.

4.3.1 Number and Types of Facilities

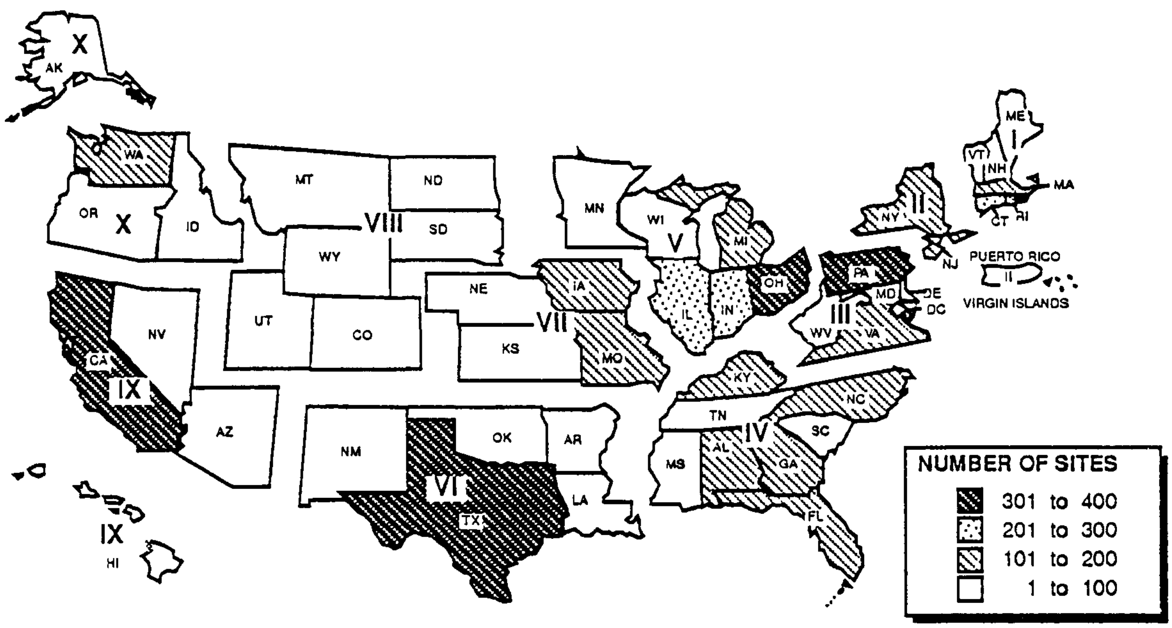
Facilities are subject to corrective action primarily due to their regulatory status as hazardous waste management TSDFs. Until further study is conducted, it is generally not known whether a TSDF will actually require remediation under the RCRA corrective action program.

Current information on the number of TSDFs subject to corrective action is contained in the Resource Conservation and Recovery Information System (RCRIS), which is the national program management and inventory system on hazardous waste handlers. Typically, EPA considers the following facilities in its universe of TSDFs to be subject to corrective action under RCRA: TSDFs with, or applying for, RCRA permits; closed or closing TSDFs; and underground injection control (UIC) facilities. Other facilities, such as those that have converted to less than 90 day storage of hazardous waste, also will be subject to corrective action but are not uniformly included in the numbers presented here. For purposes of this report, EPA also is including other facilities for which an EPA region or state has verified the existence of at least one TSD process (such as landfill or tank). These facilities are not reflected in the RCRIS TSD universe at this time.

As of May 1993, RCRIS contains 5,165 TSDFs, some of which could require corrective action (estimates range between 1,500[7] and 3,500[2] TSDFs). Approximately 7% of these facilities are federal facilities. Exhibit 4-1 presents the distribution of these facilities among the states. The exact number of TSDFs per state is provided in Exhibit A-7 in Appendix A.

RCRIS also tracks the milestones for TSDFs undergoing corrective action. Reporting begins with the issuance of enforcement orders or permits and

Exhibit 4-1: Location of RCRA Treatment, Storage, and Disposal Facilities



Note:

- Includes treatment, storage, and disposal facilities with, or applying for, RCRA permits; closed or closing facilities; and underground injection control (UIC) facilities. For the purpose of this study, also counted are other facilities for which a region or state has verified the existence of at least one treatment, storage, or disposal process.

Source: U.S. EPA, Office of Solid Waste, *RCRIS National Oversight Database*, September 1992.

continues through each step of the corrective action process. Exhibit 4-2 provides the number of TSDFs for which RFAs, RFIs, and control of releases (stabilization or corrective measures) are either ongoing or completed. Facilities conducting RFAs and RFIs may *not* require corrective action; however, action is more likely for facilities that are required to undertake RFIs.

As of the end of fiscal year 1992, 247 TSDFs had implemented or completed remedial actions to control contaminant releases, representing a substantial increase over the 136 remedial actions started or completed two years ago.[7] The large increase in actions is attributed to the stabilization initiative. RFAs have been completed for at least 3,500 facilities and RFIs are completed or ongoing for about 600 facilities. In the next several years some portion of these facilities will require corrective action.

A profile of the types of ongoing RCRA hazardous waste management operations at TSDFs may lend insight into the nature of cleanup needed at historic areas of waste management at these facilities. TSDFs may operate one or more processes for managing RCRA-regulated hazardous waste. These processes include land disposal (landfills, land treatment units, surface impoundments, waste piles, and underground injection wells), treatment or storage in tanks or containers, and incineration. Exhibit 4-3 presents the number of TSDFs reported in RCRIS that currently operate or have operated each of these processes. Each facility may be performing more than one process; therefore, the total number of processes exceeds the number of facilities. Storage and treatment in tanks or containers account for 70% of the processes reported in RCRIS. Land disposal makes up 25%, and incineration 3%. Early in the corrective action program, permit deadlines often dictated which assessments

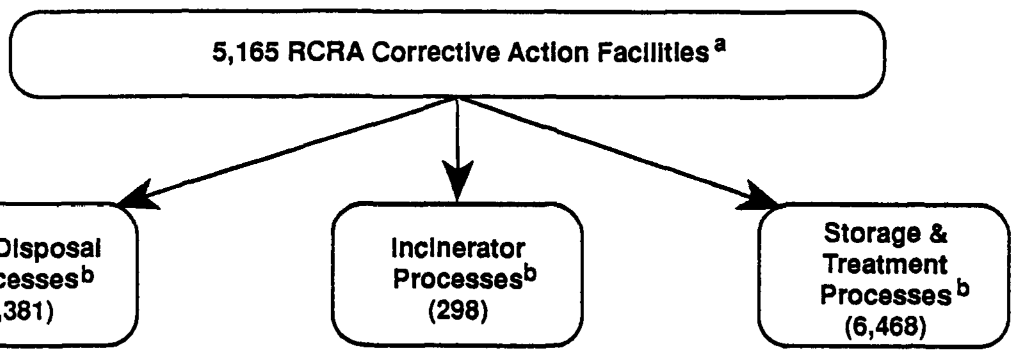
Exhibit 4-2: Status of RCRA Facilities in the Corrective Action Program as of the End of Fiscal Year 1992

Number of Facilities with RCRA Facility Assessments (RFAs) *Completed*	Number of RCRA Facility Investigations (RFIs) *Underway or Completed*	Number of RCRA Facilities Controlling Contaminant Releases *Underway or Completed*
3,519	614	247

Note: Numbers are cumulative (*e.g.*, facilities are counted for each step begun or completed) as of the end of September 1992. All facilities do not conduct RFAs and RFIs prior to remedial action and facilities conducting RFAs and RFIs may not require remedial action.

Source: RCRA Environmental Indicators, *FY 1992 Progress Report*, April 1993.

Exhibit 4-3: RCRA Treatment, Storage, or Disposal Processes



- Underground Injection (88)
- Landfill (531)
- Surface Impoundment (1,307)
  - Treatment (319)
  - Storage (689)
  - Disposal (299)
- Waste Pile (310)
- Land Treatment (145)

- Tank (2,611)
  - Treatment (783)
  - Storage (1,828)
- Container (3,152)
- Other (705)

Notes:
[a] Includes all treatment, storage, or disposal facilities inventoried in RCRIS.
[b] There may be more than one type of process per facility.

Source: U.S. EPA, Office of Solid Waste, *RCRIS National Oversight Database*, May 3, 1993.

were completed first and therefore which facilities were first determined to require corrective action.

The Agency has estimated the potential magnitude of the future corrective action needs by examining the number of SWMUs. The average TSDF has many more SWMUs than RCRA-regulated hazardous waste management units (RUs). The 1990 Regulatory Impact Analysis (RIA), conducted to support the proposed Corrective Action Rule, estimated roughly 80,000 SWMUs.[8] The 1990 RIA also projected that about 1,500 TSDFs would require corrective action for releases to ground water. EPA now expects that a much larger portion of facilities ultimately will require corrective action. A revised estimate based on a new methodology is projected to be completed in 1994.

4.3.2 Characteristics and Quantities of Hazardous Waste

Most TSDFs subject to corrective action have not yet undergone RFIs to determine the nature and extent of contamination. Therefore, data are insufficient to accurately characterize the constituents and waste volumes that will require cleanup. However, information is available on the types of industrial facilities that generate hazardous waste and the quantity of hazardous waste generated. While it is unknown whether wastes generated today actually represent the character of past waste disposal practices, these data provide some insight into the types of constituents that will be encountered during cleanup. Also, EPA expects that the types of wastes requiring remediation at TSDFs may resemble those at Superfund sites, many of which were once operating TSDFs (Exhibit 3-4).

Data on the hazardous wastes generated and managed at TSDFs are available from the 1989 Biennial Reporting System (BRS), which is managed by EPA. The BRS is a national system that collects data on the generation, management, and minimization of hazardous waste. Large-quantity hazardous waste generators and operators of TSDFs submit data every two years on the types and quantities of hazardous waste managed. Data from the 1989 BRS are published in the National Biennial RCRA Hazardous Waste Report.[9]

The BRS contains the quantities of hazardous waste managed by various treatment and disposal methods and by recovery/recycling (Exhibit 4-4). By weight, the majority of hazardous waste managed in 1989 was wastewater. Underground injection also made up a significant amount (14% by weight) of the total quantity of hazardous waste managed. After underground injection, landfills accounted for most of the hazardous waste disposed to the land. Because of the land disposal restrictions promulgated since 1989, the amount of waste managed by land disposal has probably decreased.

Information on the wastes managed by each type of hazardous waste management process is available from two surveys of the hazardous waste management industry conducted by EPA in 1986.[10] The National Survey of Hazardous Waste Generators (GENSUR) included a statistical sample of large-quantity generators that produced hazardous waste in 1986. The National Survey of Hazardous Waste, Treatment, Storage, Disposal, and Recycling Facilities (TSDR) included all facilities that in 1986 had obtained, or were in the process of obtaining, a RCRA Part B permit.

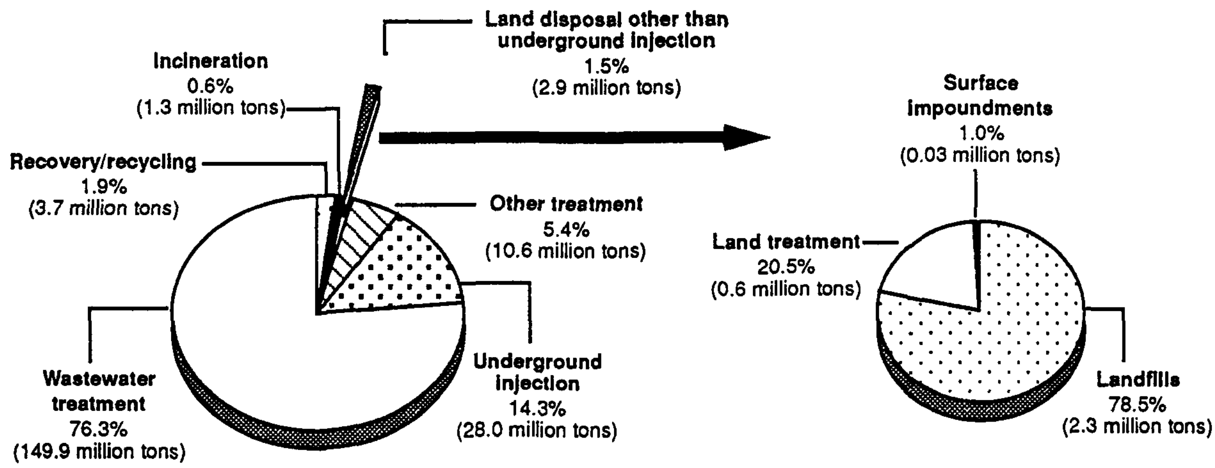
Exhibit A-8 (Appendix A) shows the most prevalent wastes found in SWMUs at RCRA facilities in 1986. According to the TSDR/GENSUR surveys, the most common wastes managed in SWMUs include corrosive (highly acidic or alkaline) waste, ignitable waste, heavy metals, organic solvents, electroplating waste, and waste oil (considered hazardous by some states).

4.4 Estimated Dollar Value of Site Cleanup

In the 1990 RIA for the proposed Subpart S rule, EPA estimated that the costs of cleaning up only contaminated ground water at corrective action sites would range between $7.4 billion and $41.8 billion. Other estimates of the total costs of corrective action also have been developed.[11]

Recently, EPA developed a new methodology for estimating the costs of implementing the corrective action program.[12] To illustrate the new approach, the new methodology was applied to the Subpart S rule proposed in 1990, although regulatory options for corrective action are still being formulated. Based on this preliminary analysis, EPA projects a total national present value program cost of about $18.7 billion, an annual cost of about $1.8 billion, and a weighted average cost per facility of $7.2 million. Roughly half of the total cost of corrective action would be incurred by slightly more than 10%

Exhibit 4-4: Amounts of Hazardous Waste Managed in 54 States and Territories in 1989



Note: Because values are rounded, percentages vary slightly from Biennial Report.

Source: U.S. EPA, Office of Solid Waste, *National Biennial RCRA Hazardous Waste Report (Based on 1989 Data)*, February 1993.

of the RCRA TSDFs. These values are likely to change when the final regulations are promulgated.

4.5 Market Entry Considerations

The responsibility for RCRA corrective action at individual facilities rests with the owners and operators who contract directly with commercial vendors for services. Because there is no centralized source of TSDF information, vendors interested in this market may have to contact specific owners or operators to obtain facts on an individual facility's waste characteristics, cleanup requirements, and whether corrective action will be required. State hazardous waste agencies and the EPA Regional Offices have some knowledge about corrective action needs of facilities in their state or region. Addresses for these agencies may be found in Appendix B.

4.6 Remedial Technologies

EPA Regional Offices are currently gathering information on the remedies selected for RCRA corrective action. Initial data on 60 TSDFs at which soil remediation is planned, ongoing, or completed reveal that of approximately 70 soil remedial measures, about half are off-site disposal remedies (landfilling or incineration) and half are innovative treatment. Of the innovative technologies, about one-third are soil vapor extraction, one-third are *in situ* bioremediation, and one third are above-ground treatment, primarily bioremediation. These trends in the selection of innovative technologies are similar to those in the Superfund program. However, these data are not complete; it is likely that this sample missed the use of solidification/stabilization, which is commonly used in the Superfund program.

4.7 References

1. U.S. Environmental Protection Agency, Office of Solid Waste, "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities; Proposed Rule (40 CFR Parts 264, 265, 270, and 271)," 55 *Federal Register*, No. 145, pp. 30798-30884, July 27, 1990.

2. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "The Nation's Hazardous Waste Management Program at a Crossroads: The RCRA Implementation Study," EPA/530-SW-90-069, 1990.

3. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "FY 1992 RCRA Implementation Plan," OSWER Directive 9420.00-07, 1992.

4. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "FY 1993 RCRA Implementation Plan," OSWER Directive 9420.00-08, 1992.

5. U.S. Environmental Protection Agency, Office of Solid Waste, "RCRA Stabilization Strategy," October 25, 1991.

6. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Regional Guide to Issuing Site Specific Treatability Variance for Contaminated Soils and Debris From Land Disposal Restrictions," OSWER Directive 9389.3-08FS, January 1992.

7. U.S. Environmental Protection Agency, Office of Solid Waste, "RCRA Implementation Factors, FY 1992 Progress Report," April 1993.

8. U.S. Environmental Protection Agency, Office of Solid Waste, "Regulatory Impact Analysis for the Proposed Rulemaking on Corrective Action for Solid Waste Management Units," RCRA Docket No. CASP-S0062, 1990.

9. U.S. Environmental Protection Agency, Office of Solid Waste, "National Biennial RCRA Hazardous Waste Report Based on 1989 Data," EPA 530/R-92/027, NTIS No. PB 93-148245, February 1993.

10. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "Summary of SWMUs at Facilities Needing Corrective Action, Revised," Research Triangle Institute Project No. 5100-11-01, 1992.

11. Tonn, B., M. Russell, H.L. Hwang, R. Goeltz, and J. Warren, "Costs of RCRA Corrective Action: Interim Report," Oak Ridge National Laboratory, Oak Ridge, TN, ORNL/TM-11864, December 1991.

12. U.S. Environmental Protection Agency, Office of Solid Waste, "Draft Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units: Proposed Methodology for Analysis," March 1993.

CHAPTER 5 DEMAND FOR REMEDIATION OF UNDERGROUND STORAGE TANK SITES

Millions of underground storage tanks (USTs) containing petroleum products or hazardous chemicals are located throughout the United States. USTs are used by a wide variety of industries, such as petroleum and chemical manufacturing and distribution companies, fleet owners, farmers, and government agencies. Over 1.6 million of the tanks are subject to federal regulations, and about 91% of these contain petroleum products, including used oil. Only 2% contain hazardous material.

Releases of petroleum or hazardous substances can result from a spill during tank filling operations, leaks in the system due to corrosion, structural failure of the tank or pipes attached to the tank, or faulty installation. More than 180,000 releases at tank facilities have been confirmed to date, and more are expected. These releases can contaminate soil and ground water and cause fires or explosions.

Subtitle I of the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA), was enacted in 1984 to control and prevent leaks and spills from USTs. Subtitle I governs USTs storing regulated substances, including gasoline, crude oil, other petroleum products, and hazardous substances defined under the Superfund program. Pursuant to Subtitle I, EPA has promulgated regulations that require, among other things, that leaks and spills be detected and reported, contamination caused by leaks and spills be remediated, future releases be prevented, and each state have a regulatory program for USTs that is at least as stringent as that under the federal regulations. These regulations have compelled cleanup activities at many UST sites, providing opportunities for the application of a variety of remedial technologies.

5.1 Program Description

The federal regulatory program is implemented by EPA's Office of Underground Storage Tanks (OUST). The federal UST performance standards and state program requirements were promulgated in September 1988, and became effective on December 22, 1988.[1] These regulations will, to a large extent, determine the size of the market for cleanup services.

The regulations apply to any UST, except those specifically exempted, used to store petroleum products or substances defined as hazardous under CERCLA. The regulations do not apply to tanks storing hazardous wastes, which are regulated under Subtitle C of RCRA. An UST is defined as any tank that has at least 10% of its volume buried below ground, including piping connected to the tank. Generally, the requirements for both chemical and petroleum tanks are similar.

The basic federal requirements include:

- A tank owner must register its tank(s) with the state authority by completing a notification form about the characteristics and contents of the UST.
- A tank owner must institute a periodic leak detection program to actively seek out releases. For tanks installed after December 1988, leak detection requirements become effective at installation. For older tanks, the requirements will be phased in by December 1993.
- A tank owner must maintain records of leak detection activities, corrosion protection system inspections, repair and maintenance activities, and post-closure site assessments.
- A tank owner must notify the appropriate regulatory authority of all suspected or confirmed releases as well as follow-up actions taken or planned. Suspected leaks must be investigated immediately to determine if they are real. If evidence of environmental damage is the cause for suspicion, it must be reported immediately to the regulatory authority.

- If a leak or spill is confirmed, tank owners must (a) take immediate action to stop and contain the leak or spill, (b) notify the regulatory authority within 24 hours, and (c) take action to mitigate damage to people and the environment.

- By December 1998, USTs installed before December 1988 must have corrosion protection for steel tanks and piping, and devices that prevent spills and overfills.

- A tank owner must notify the regulatory authority 30 days before permanently closing an UST.

In addition to providing performance standards, the regulations establish requirements that a state must meet to receive EPA approval for its program. State or local authorities may have requirements that are somewhat different or more stringent. All states and territories have passed legislation for UST cleanups, and 43 states have state trust funds. The following kinds of tanks are currently *exempt* from the regulations:

- Farm and residential tanks holding 1,100 gallons or less of motor fuel used for non-commercial purposes;
- Tanks storing heating oil used on the premises where it is stored;
- Storage tanks on or above the floor of areas such as basements or tunnels;
- Septic tanks and systems for collecting storm water and wastewater;
- Flow-through process tanks;
- Tanks holding 110 gallons or less; and
- Emergency spill and overfill tanks.

Changes in the types of tanks covered by the regulations could significantly impact the potential size of the market. However, EPA is not contemplating any such changes at this time.

5.2 Factors Affecting Demand for Site Cleanup

The demand for remediation services at contaminated UST sites primarily will be influenced by federal regulations, state requirements, and the number of releases occurring at old and new tanks. Specifically, the following factors affect this market:

- The implementation of leak detection requirements (which become effective in 1993), in combination with the reporting requirements, have led to an increase in the number of confirmed releases. This increased rate of release reports is likely to continue over the next several years.

- The implementation of tank upgrading requirements, which become effective in 1998, is also expected to cause an increase in the number of reported releases.

- Over a longer period of time, it is anticipated that the rate of occurrence of confirmed releases will fall, because the failure rate of tanks will eventually fall as a result of improved tank systems.

- Some states have promulgated requirements that are more stringent than the federal standards, such as a requirement for double-lined tanks or more stringent monitoring procedures. Such requirements would increase the potential market by accelerating the updating, replacement, or closure of tanks.

- The pace of the cleanups will be affected by the adequacy of funding and the requirements of reimbursement funds used by 43 states to help pay for needed cleanups. Most of the cost of UST cleanups in these states are now paid out of these funds, and some of them do not have sufficient money to clean up all of the eligible sites. The federal trust fund accounts for only a small portion of UST cleanup activity.

- The failure rate of tank systems is determined by such factors as tank age, material of construction, corrosion protection systems in place, and other design features. Because of these factors, and because the federal and state requirements are still evolving, estimates of market size cannot be precise. The estimates in the following section are based on the current RCRA requirements and available data.

5.3 Number and Characteristics of Sites

The data on the number, size, contents, construction materials, and other parameters of tanks are derived from data compiled by EPA from reports it receives from 56 states and territories. The states compile their data from notification forms received from tank owners. Reporting quality varies among the states and has resulted in some under-reporting of the number of tanks subject to the regulations. Estimates of the extent of under-counting range from 15% to 80%.[a] For purposes of this report, it is assumed that about 25% of the tanks that are required to register do not do so. EPA reports most of these data in terms of the numbers of tanks. However, for purposes of this study, the data are converted to "number of UST sites." EPA estimates that there is an average of 2.7 tanks per UST site, although the number actually varies widely from one site to another.

5.3.1 Number of Sites

EPA reports that, as of May 1992, 1,565,613 USTs were registered in the U.S. Assuming that 25% of regulated USTs are not registered, there are a total of 2,087,484 tanks; and using EPA's estimated average of the 2.7 tanks per site, approximately 773,000 sites with USTs are subject to the regulations. These estimates are shown in Exhibit 5-1. Estimates of the percentage of sites that are likely to leak and require cleanup of contaminated soils or ground water are presented later in this section.

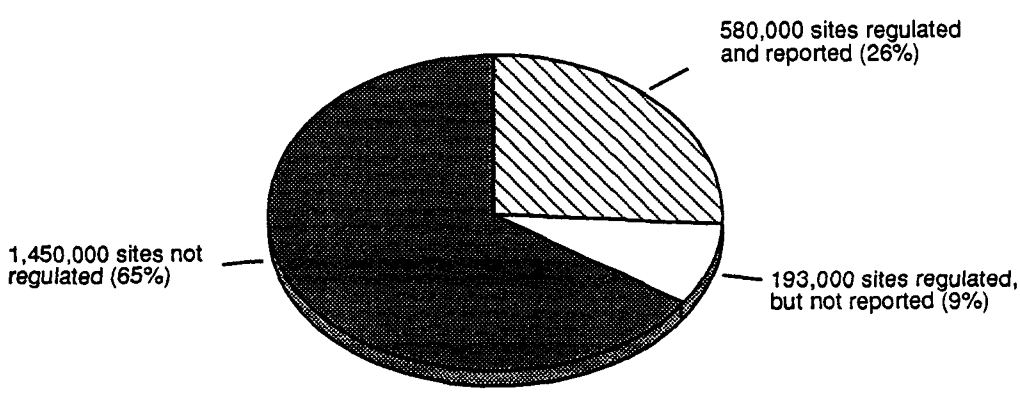
Also shown in Exhibit 5-1 is the estimated total number of all tanks sites, including those not covered by federal regulations. An additional 1.45 million sites are exempt from the regulations and are not included as part of the market for remediation services in this report.

The following sections describe some basic characteristics of the federally regulated sites, such as the contents, ownership, size, and age, based on data collected by EPA in 1991.

5.3.2 Contaminants Found at UST Sites

The substances stored in RCRA-regulated tanks are depicted in Exhibit 5-2. Most USTs contain petroleum products, which are mixtures of four types of hydrocarbons: paraffins, olefins, napthalenes, and

Exhibit 5-1: Estimated Number of Federally Regulated UST Sites



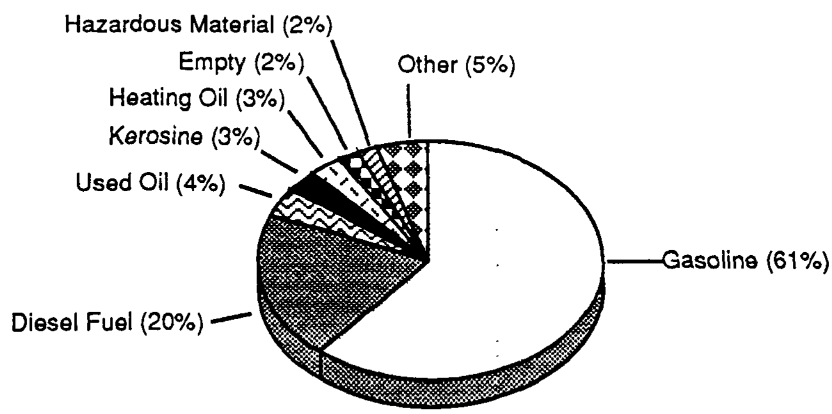
Total Underground Storage Tank Sites = 2,223,000

Source: U.S. EPA, Office of Underground Storage Tanks, *Quarterly Activity Reports*, October 1992, and estimates explained in text.

[a] Bueckman, Donna S., S. Kumar, and M. Russell, *Underground Storage Tanks: Resource Requirements For Corrective Action*, pages 17-19 and 31, Waste Management Research and Education Institute, University of Tennessee, December 1991 reports this range based on a review of several surveys. Based on this review, the authors estimate the average under-counting for the country to be 35%. However, this study uses a 25% estimate, to ensure that the market size is not overestimated.

aromatics. The literature provides extensive data on the concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) in gasoline and diesel fuel, but information on the concentration of these constituents in other petroleum products is more limited. BTEX compounds also have been detected in soil and other media at UST sites where gasoline is stored.[2]

Exhibit 5-2: Contents of Federally Regulated Tanks



Source: U.S. EPA, Office of Underground Storage Tanks, *National Survey of Underground Storage Tanks*, Spring 1991.
U.S. EPA, Office of Underground Storage Tanks, *TC [Toxic Characteristic] Study of Petroleum Contaminated Media*, Draft, July 1992.

5.3.3 Quantities of Contaminated Material

The volume of soil to be cleaned up varies widely from one site to another. A 1990 EPA survey provided data from 16 states on the average volume of soil and debris excavated at UST sites. The median volume for the 16 states ranged from 9 to 800 cubic yards, with a weighted average of 190. Multiplying this average by the number of sites expected to need remediation (295,000) results in an estimated 56.1 million cubic yards of material needing remediation.

5.3.4 Ownership of Tanks

Private companies and individuals own 69% of the tanks, state and local governments own 8.4%, and the federal and Native American governments own 2.2%. Ownership of the remaining 20% is unknown.

5.3.5 Size and Age of Tanks

The size and age of a tank may contribute to the extent of the contamination and to the type of work needed at a site. Exhibit 5-3 shows the number of tanks of different sizes reported in the EPA survey, as of the Spring 1991. Almost two-thirds of the tanks are between 2,000 and 30,000 gallons, and 28% are between 110 and 2,000 gallons.

Exhibit 5-4 shows the age of federally regulated tanks, including closed tanks. The probability of a leak is directly related to tank age, and 28% of regulated tanks are over 25 years old. Data are not available on the number of older tanks that have been remediated and closed.

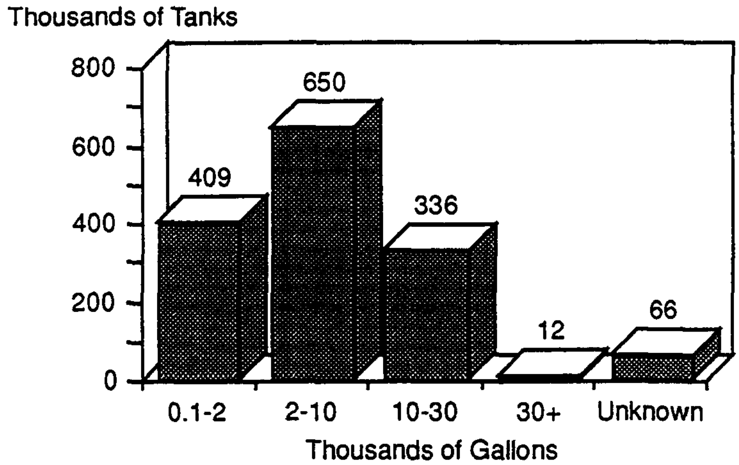
5.3.6 Location of Regulated Tanks

Appendix A, Exhibit A-9 lists the number of regulated tank sites by state. California, Texas, Michigan, Ohio, Wisconsin, Illinois, Pennsylvania, and North Carolina contain over 40% of the U.S. total. The location data should be used with caution because the number of tanks in a state may not be correlated with the number of releases, and reporting quality varies among the states.

5.3.7 Potential Number of Sites to be Cleaned Up

The demand for remediation of contaminated UST sites will be determined by the number of sites with releases and the amount of remediation work needed per site. These variables have not been precisely determined. The data on the factors that cause and aggravate releases are not available and the impacts of the RCRA requirements on the number of potential sites are unknown. Thus, the estimates presented in this section incorporate simplifying assumptions regarding some of these variables.

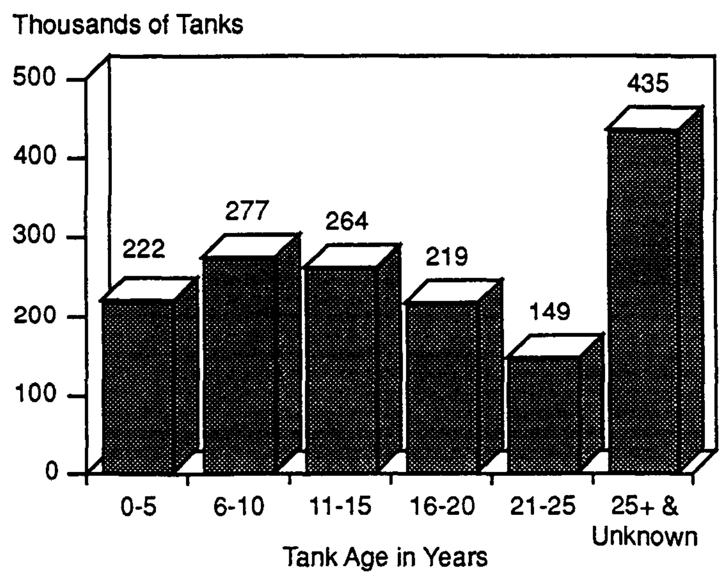
Exhibit 5-3: Size of Federally Regulated Tanks



Note: Based on reports on 1.6 million tanks, including closed tanks.

Source: U.S. EPA, Office of Underground Storage Tanks, *National Survey of Underground Storage Tanks*, Spring 1991.

Exhibit 5-4: Age of Federally Regulated Tanks



Note: Based on reports on 1.6 million tanks, including closed tanks.

Source: U.S. EPA, Office of Underground Storage Tanks, *National Survey of Underground Storage Tanks*, Spring 1991.

EPA has estimated that the number of confirmed releases will total 360,000 by 1997.[b] By September 1992, about 184,000 of these releases had already been reported to EPA, and remedial design or remedial action had been initiated at 65,000 of these sites. This results in an estimated remaining remediation market of 295,000 sites (Exhibit 5-5).

Although the size of the entire market has been estimated, the year-to-year fluctuations in cleanup efforts are difficult to predict. EPA estimates that the RCRA UST requirements will probably cause an increase in the number of releases reported, followed by a decrease. The increase will result from the phase-in of leak detection requirements in 1993 and tank upgrading requirements in 1998. The decline in confirmed releases will result from the improvements in the types of tank systems in place and leak detection and monitoring practices required by RCRA. EPA estimates that it will take 20 to 30 years to remediate all sites. Exhibit 5-6 shows the quarterly activity in corrective actions for the past three years. The demand for cleanup services has been growing faster than cleanups have been initiated or completed.

5.4 Estimated Dollar Value of Site Cleanup

Based on a review of literature and data, the University of Tennessee reported that the cost of remediating UST sites vary widely, generally between $2,000 to over $400,000. Costs at individual sites can exceed a million dollars.[3] Based on experience with a limited number of projects, EPA estimates that the average remediation cost per site is $100,000. This cost estimate includes treatment or disposal of soil and ground water, site investigations, and feasibility studies, but does not include costs related to excavating, disposing of, or repairing tanks and related equipment such as piping. Multiplying this average by the number of sites expected to need remediation (295,000), the projected total remediation cost is $29.5 billion.

The timing of these expenditures from year-to-year cannot be determined, although it has been estimated that the cleanup of all known and projected sites will take 20-30 years. It is anticipated that cleanup activities will increase as the various regulatory deadlines approach

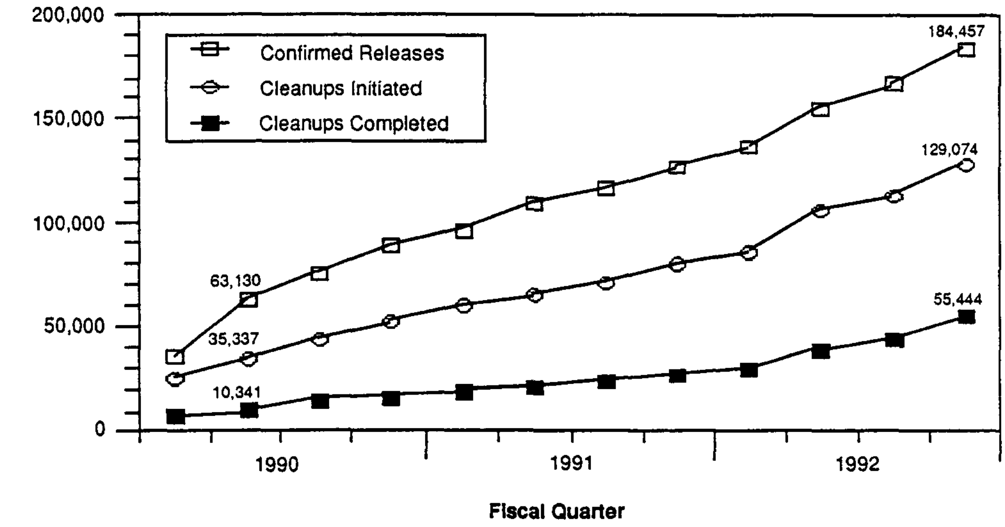
Exhibit 5-5: Estimated Number of UST Sites Requiring Cleanup

	Reported to EPA	Sites with Future Releases	Total
Confirmed Releases	184,000	176,000	360,000
Cleanups in RA or RD[a]	65,000	0	65,000
Future Cleanups Required[b]	119,000	176,000	295,000

Notes:
[a] As of September 1992, cleanup activities have been initiated at 129,000 sites. Of these, EPA estimates that 65,000 sites are in the remedial action or remedial design stage. The remaining 64,000 are still in the early stages of investigation, and are, therefore, included in "Future Cleanups Required."
[b] "Future Cleanups Required" is derived by subtracting "Cleanups in RD or RA" from "Confirmed Releases."

[b] Although the number of confirmed releases may not precisely equal the number of sites with releases, OUST estimates that the difference is small. Therefore, for the purpose of this analysis it is assumed that the number of confirmed releases equals the number of sites with releases.

Exhibit 5-6: Status of UST Corrective Actions (Cumulative)



Note: About half of the cleanups initiated have not begun remedial design or remedial action, and, therefore, are counted in the demand estimate.

Source: U.S. EPA, Office of Underground Storage Tanks.

(December 1993 for leak detection; and December 1998 for corrosion protection and spill and overfill prevention).

5.5 Market Entry Considerations

The following factors will be important to the success of vendors operating in the UST remediation market:

- Site work is primarily the responsibility of tank owners, especially of establishments such as retail gasoline stations, fleet maintenance facilities, auto repair facilities, manufacturing facilities, mining sites, transportation facilities, and petroleum and chemical marketers.

- Enforcement activity varies from one state to another. In addition, some states regulate tanks that are not regulated under RCRA. State authorities may be able to provide information on their programs.

- Often, an UST owner's first indication of contamination comes from a tank testing and replacement contractor. These companies also may be hired to coordinate any necessary remediation. Often the work is done in conjunction with tank replacement or upgrading. Treatment or disposal of contaminated soils and ground water usually are subcontracted to a company that specializes in the appropriate remedy. Vendors that specialize in environmental restoration may seek to team with companies that specialize in tank testing or replacement.

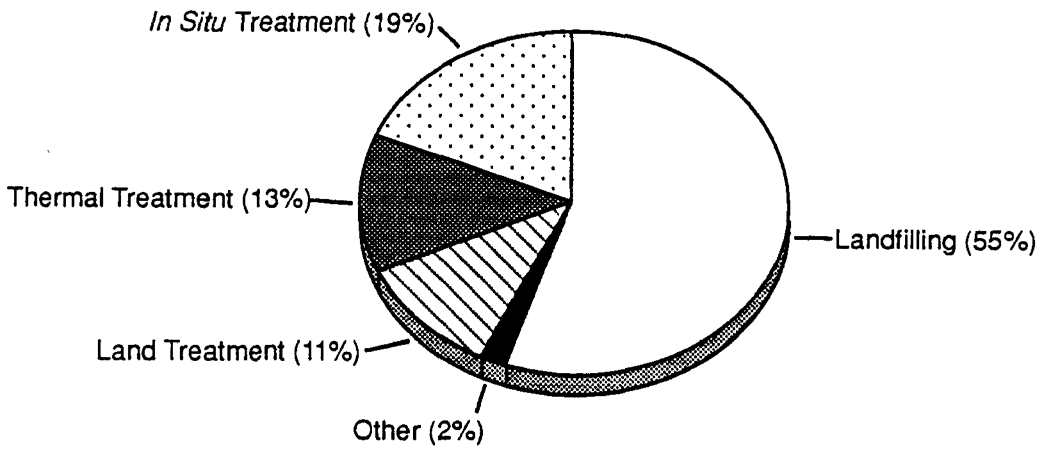
- As tank testing and other requirements are implemented, the extent of cleanup activities and costs per site probably will decrease. Thus, economical ways to remediate smaller releases may be needed.

5.6 Remedial Technologies

Data on the kinds of innovative technologies used to remediate contaminated UST sites have not been centralized. For petroleum contaminated soils, which account for more than 90% of USTs, a recent EPA study presented information on the kinds of technologies used for cleanups.[4]

Exhibit 5-7 shows frequencies of use for the major categories of treatment and disposal methods (*in situ* treatment, landfilling, thermal treatment, and land treatment). Exhibit 5-8 shows a more detailed

Exhibit 5-7: Frequencies of Major Categories of Site Remediation Methods for Petroleum Contaminated Soils at UST Sites

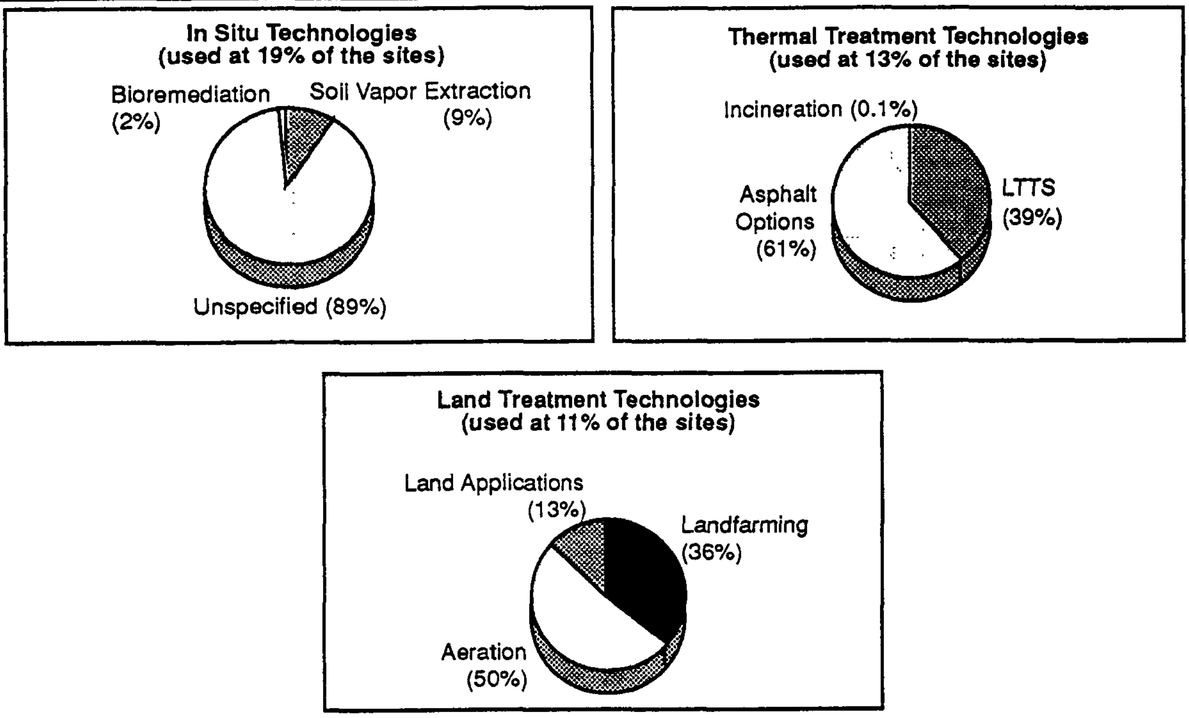


Note: These percentages are based on an OUST survey of officials in 22 states conducted between August 1990 and July 1991.

Source: U.S EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office and Office of Underground Storage Tanks, *Technologies and Options for UST Corrective Actions: Overview and Current Practice*, EPA/542/R-92/010, August 1992.

breakdown of the *in situ*, thermal, and land treatment categories. Over 32% of the UST site corrective actions in the states that responded to the survey questions use innovative technologies. Exhibit 5-9 lists specific technologies typically used for petroleum-contaminated soils at UST sites. However, the frequencies of use of these technologies were not reported. The use of innovative technologies may help accelerate the pace of, or reduce the cost of, remediating UST sites. However, most sites tend to rely on more traditional approaches. The use of innovative technologies is often hampered by a lack of cost or performance data, a lack of expertise on the part of state and contractor personnel, or additional permit requirements. To help overcome some of these barriers, the EPA is planning several demonstration projects within the next several months to test several innovative technologies at UST sites. Technologies to be evaluated are soil vapor extraction, air sparging, enhanced bioremediation, and low-level thermal desorption. EPA also is working with tank owners to test innovative technologies at UST sites in EPA's Region V (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin), and expects to publish cost and performance data.

Exhibit 5-8: Frequencies of Specific Technologies Used for Petroleum Contaminated Soils at UST Sites



Note: LTTS is low temperature thermal stripping.

Source: U.S EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office and Office of Underground Storage Tanks, *Technologies and Options for UST Corrective Actions: Overview and Current Practice*, EPA/542/R-92/010, August 1992.

Exhibit 5-9: Technologies Currently Used for Managing Petroleum Contaminated Soils at UST Sites

Ex Situ Management of Soils	*In Situ* Management of Soils	Management of Ground Water
Low temperature thermal strippers	Soil vapor extraction	Free product recovery
Hot mix asphalt plants	Bioremediation	Pump and treat
Landfilling		
Land treatment		
Cold mix asphalt plants		
Stabilization and solidification		
Cement kilns		
Biological processes		

Source: U.S. EPA, Office of Solid Waste and Emergency Response, Technology Innovation Office and Office of Underground Storage Sites, *Technologies and Options for UST Corrective Actions: Overview and Current Practice*, EPA/542/R-92/010, August 1992.

5.7 References

1. U.S. Environmental Protection Agency, Office of Underground Storage Tanks, "Technical Requirements and State Program Approval, Final Rule," 53 *Federal Register*, No. 185, September 23, 1988.

2. U.S. Environmental Protection Agency, Office of Underground Storage Tanks, "TC [Toxicity Characteristic] Study of Contaminated Media and Debris," Draft, July 1992.

3. Bueckman, D.S., S. Kumar, and M. Russell, "Underground Storage Tanks: Resource Requirements for Corrective Action," University of Tennessee, Waste Management Research and Education Institute, Knoxville, TN, December 1991.

4. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office and Office of Underground Storage Tanks, "Technologies and Options for UST Corrective Actions: Overview and Current Practice," EPA/542/R-92/010, August 1992.

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CHAPTER 6
DEMAND FOR REMEDIATION OF DEPARTMENT OF DEFENSE SITES

The Department of Defense (DOD) has undertaken an ambitious environmental restoration program at thousands of facilities throughout the U.S. and its territories. These facilities contain soil, ground water, and other media that have been contaminated as a result of numerous industrial, storage, training, and testing activities. Typical contaminants include petroleum products, solvents, heavy metals, polychlorinated biphenyls (PCBs), pesticides, and explosives residues.

As of September 30, 1991, DOD had identified 17,660 sites located at 1,877 DOD installations, and 6,786 "Formerly Used Defense Sites" (FUDS) with potential hazardous waste contamination involving soil or ground water. Of these, DOD estimates that 7,313 sites will require cleanup.[1] The remaining sites have either been cleaned up, are currently being cleaned up, or do not require further work. DOD is committed to bringing all these facilities into compliance with environmental regulations within the next 20 years.

To date, DOD has concentrated most of its efforts on investigating the extent of the environmental problems at these sites. Future efforts will include more remedial activities. To accomplish the cleanups, DOD will need the services of firms that can address wastes similar to those found at private sector industrial facilities as well as firms that can remediate wastes unique to DOD, such as unexploded ordnance.

6.1 Program Description

The task of coordinating the evaluation and cleanup of contamination at DOD sites has been assigned to the Defense Environmental Restoration Program (DERP), which is managed centrally by the Deputy Assistant Secretary of Defense (Environment). The Superfund Amendments and Reauthorization Act of 1986 (SARA) authorizes DOD to carry out this program in consultation with EPA. DERP is managed within the overall framework of SARA and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

DERP includes two major components: Other Hazardous Waste Operations (OHW) and the Installation Restoration Program (IRP). OHW examines current operations to find cost-effective approaches to DOD's waste management activities and prevent pollution at the point of generation. Included in this program are research, development, and demonstration (RD&D) of pollution prevention and hazardous waste management technologies. These efforts involve study of unexploded ordnance detection and range clearance methods; investigation of alternative products (substitution); revision of specifications; improvement of acquisition and operating practices; procurement of hazardous waste reduction equipment; exchange of information; and other environmental restoration and pollution prevention activities.

Under the IRP, which is the primary focus of this chapter, DOD cleans up all contaminated sites that are required by environmental statutes. Although policy direction and oversight of IRP is the responsibility of the Deputy Assistant Secretary of Defense, each individual defense service (Army, Navy, Air Force, and Defense Logistics Agency) is responsible for program implementation.

DERP has specified procedures for evaluating sites and procuring cleanup services under IRP that conform to the requirements of the National Oil and Hazardous Substances Contingency Plan (NCP), and follow EPA guidelines for site investigations and remediation. These procedures cover all phases of site operations, including preliminary assessment (PA), site inspection (SI), remedial investigation/feasibility study (RI/FS), remedial design (RD), and remedial action (RA). In general, activities related to preliminary assessment through remedial design are conducted by contractors other than those that conduct remedial action.

In selecting and designing remedies, DOD officials coordinate with EPA regional officials to ensure that cleanup goals meet regulatory requirements. Most contracting is done on an installation-oriented basis, either through centralized contracting service centers or directly by the installation. Although each service follows general procedures specified by DERP, each procures its own services.

6.2 Factors Affecting the Demand for DOD Site Cleanup

The following factors may impact the market for remediation of DOD sites:

- DOD believes most sites have been located.[a] In 1989 and 1990 the number of sites identified for listing in the IRP increased 115%; in 1991 it increased only 1%.

- The pace of remediating sites is subject to change in response to general budgetary and political developments. Based on the fiscal year 1991 rate, DOD has estimates that all the identified sites will be cleaned up by 2011. DOD anticipates that remedial design and remedial action work will increase until 1998 and then slow at a moderate rate until all the RA work is completed.[1]

- Because the nature and magnitude of the contamination at many identified sites are still only partially known, and because experience and data from past remedial actions are limited, cleanup requirements are uncertain. Within the next several years, DOD is expected to complete a thorough characterization of its contamination problem and cleanup needs. In addition, information on past cleanup activities will contribute to a more accurate assessment of cleanup needs.

- DOD gives top priority to cleanup activities necessary to prevent near-term adverse impacts to workers, the public, or the environment, and to activities required to satisfy agreements with local, state, or other federal agencies. This policy may occasionally lead to postponements at other sites.

- The rate of base closures and realignments will affect the scheduling of site cleanup. Prior to closing or realigning a base, DOD may be required to clean up the site. The Base Closure and Realignment Acts of 1988 (BRAC 88) and 1990 (BRAC 90) designated 113 military bases for closure and another 62 installations for realignment. Congress provided $220 million during fiscal year 1992 for environmental restoration at bases scheduled for closure.

- As with other site remediation programs, changes in regulatory requirements also may affect cleanup goals, technologies used, and costs.

6.3 Number and Characteristics of Sites

The data on the number, size, contents, and other characteristics of DOD sites are derived from data compiled by the DERP from reports it receives from each of the services.

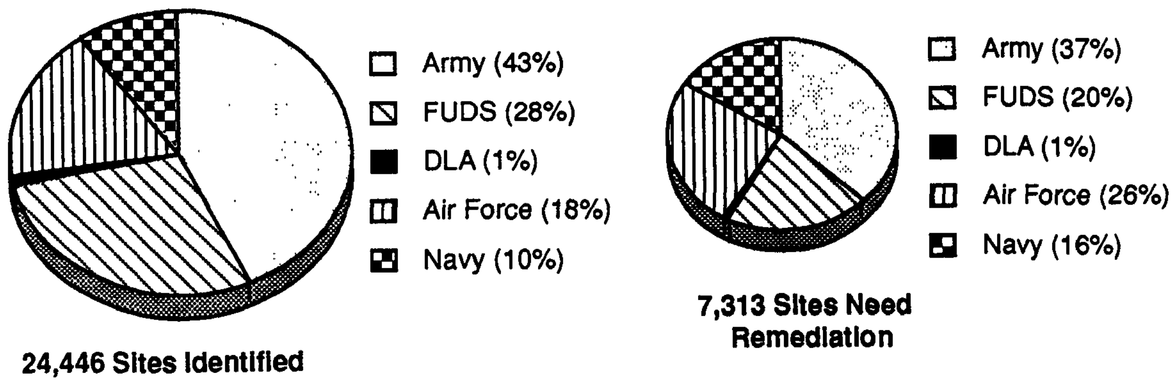
6.3.1 Number of Sites

As stated earlier, DOD has estimated that 7,313 sites are likely to require remedial action. Exhibit 6-1 shows the number of sites in each service likely to require remediation services. The Army has the greatest number (37%), followed by the Air Force, Navy, and the Defense Logistics Agency (DLA). Although FUDS are managed by the Army, they are the result of activities of all the services.

Exhibit 6-2 lists the number of sites within each service needing remediation, by site category. In deriving these estimates, DOD assigned each site to one category, even though some sites may have multiple activities. Thus, the number of sites in any specific site category may be underestimated. Exhibit A-10 (Appendix A) provides definitions of 20 categories of sites used in coding data in the Defense Environmental Restoration Program Management Information System (DERPMIS).[2]

[a] These data do not include third party sites (TPS), which are sites that have never been owned or operated by DOD, but for which DOD may be a potentially responsible party (PRP). DERP estimates that through fiscal year 2000 DOD will spend $762 million in total liability costs for these sites.

Exhibit 6-1: DOD Sites by Service Component



Source: DOD, Defense Environmental Restoration Program, *Annual Report to Congress for Fiscal Year 1991*, February 1992.
DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate*, September 1991.

DERP derived these estimates from data in DERPMIS and other information provided by the DOD services. Because the SIs and RI/FSs for many of these sites have not been completed, the estimates may be revised in the future.

6.3.2 Types of Contaminants

Data on the types of contaminants found at DOD sites can indicate what kinds of technologies will be needed to clean them up. Although DERPMIS does not contain contaminant data on all 7,313 sites, data are available for 3,943 sites (54%) which are likely to be representative of the types of contaminants that need to be addressed.

Exhibit 6-3 shows the contaminant groups that are coded in DERPMIS, along with indications of the frequencies of occurrence. Exhibit A-11 (Appendix A) provides the frequencies of the most common contaminant groups for each site category.

The most frequently reported wastes are petroleum-related products, VOCs, PCBs, metals, solvents, and explosives. Most of these waste groups are also frequently found at waste sites associated with non-defense industrial facilities. Also, a number of sites contain contaminants, such as unexploded ordnance or low level radiation, that are less frequently found in industry and thus present unique problems for selecting remediation approaches.

DERPMIS does not provide information on the specific compounds found throughout DOD. However, a 1990 study of over 7,000 sampling locations at 196 Air Force installations identified the ten most common organic compounds found in ground water at these sites. In order of relative frequency, these are TCE, toluene, benzene, phenolics, PCE, ethylbenzene, 1,1,1-TCA, trans-1,2-DCE, 1,4-dichlorobenzene, and 1,1-DCA.[3]

6.3.3 Quantity of Contaminated Soil

Many DOD remedial actions will require treatment or removal of contaminated soil. Although DOD has not estimated the total quantity of materials to be remediated, it has estimated "typical" quantities of contaminated soil for 9 of its 20 site categories. DOD developed these data based on model sites that are representative of the size, types of wastes, media, and other parameters of DOD sites. The quantities for these models range from 700 cubic yards of contaminated soil to be remediated per site for a typical small fire/crash training area to 9,500 cubic yards for a typical large storage area (Exhibit

Exhibit 6-2: Number of Sites to be Remediated by Service and Site Category

Site Category[a]	Army	Navy	Air Force	DLA	FUDS	Total
Aboveground Storage Tank[b]	85	17	31	0	NA[b]	133[b]
Large Burn Area	49	0	0	7	0	56
Small Burn Area	0	40	25	0	0	65
Contaminated Ground Water	26	9	12	2	0	49
Contaminated Sediment						
Large	0	22	0	0	0	22
Small	4	0	79	4	0	87
Contaminated Building	184	26	1	0	0	211
Disposal Pit/Dry Well	67	141	98	34	0	340
Explosive/Ordnance Disposal Area	32	23	10	0	118	183
Fire/Crash Training Area						
Large	0	0	199	1	0	200
Small	16	71	0	0	0	87
Large Landfill	218	10	174	2	0	404
Small Landfill	0	166	174	3	0	343
Petroleum, Oil, Lubricant (POL) Line	0	9	34	0	0	43
Spill Area	109	141	331	4	0	585
Storage Area						
Large	75	0	0	19	0	94
Small	670	116	109	0	0	895
Surface Disposal Area	126	211	127	0	0	464
Surface Impoundment/Lagoon	191	35	61	2	0	289
Underground Storage Tank Area[b]	435	57	267	3	826[b]	1,588[b]
Waste Line	8	20	8	0	0	36
Waste Treatment Plant						
Large	72	0	8	0	0	80
Small	0	13	8	0	0	21
None of the Above	363	36	111	0	0	510
Hazardous and Toxic Waste	NA	NA	NA	NA	531	531
Totals	2,728	1,163	1,867	80	1,475	7,313

Notes:
[a] The definitions of site types appear in Appendix A, Exhibit A-10.
[b] The estimate for FUDS storage tanks includes both underground and aboveground tanks.

Source: DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate,* September 1991.

Exhibit 6-3: Most Frequently Reported Contaminant Groups at DOD Sites (Percents refer to the frequency of occurrence of the contaminant)[a]

Air Force (of 1,834 Sites)	%[a]	Army (of 1,114 Sites)	%[a]	Navy (of 995 Sites)	%[a]
Petroleum, Oil, or Lubricants (POL)	34	Heavy Metals	25	Petroleum,Oil, & Lubricants	38
Solvents	11	Ordnance Components	17	Solvents	22
Refuse with Hazardous Waste	6	Petroleum, Oil, & Lubricants	15	Paints	12
Refuse without Hazardous Waste	4	Explosive Chemicals	9	Heavy Metals	11
Paints	3	Pesticides	7	PCBs	9
Heavy Metals	2	Solvents	7	Pesticides	7
Inert Material	2	Chlorinated Solvents	7	Acids	6
Pesticides	2	Inert Material	6	Petroleum, Oil, & Lubricants, Sludge	4
Industrial Sludge	2	Petroleum, Oil, & Lubricants, Sludge	6	Refuse without Hazardous Waste	4
PCBs	2	Scrap Metal	4	Industrial Wastewater	4
Other, Unknown & Unspecified[b]	50	Other, Unknown, & Unspecified[b]	49	Other, Unknown, & Unspecified[b]	26

Notes:

[a] These percentages reflect the number of sites where a contaminant is identified relative to the number of sites in the service for which data have been reported. The total of the percentages are greater than 100 because most sites contain more than one type of contaminant.

[b] The "other" category includes contaminants labeled as "other," "unknown," or "unspecified" in DERPMIS.

Source: Analysis of data from DOD's Defense Environmental Restoration Program Management Information System, June 1992, provided by DERP.

6-4). These estimates are based on "typical" sites, and values may vary from one site to another.

6.4 Estimated Dollar Value of Site Cleanup

DOD's estimate of the costs of remediation were developed from the aforementioned "model" site characteristics. DOD developed a cost estimate for each type of site using either EPA's Cost of Remedial Action (CORA) computer model, the Navy's version of the CORA model, or costs provided by the services.[b] Exhibit 6-5 shows the DOD-estimated remedial action costs by service and type of site. DOD estimates that RD/RA will cost $15.4 billion (1991 dollars), of which $1.4 billion will be for RD. In addition, operation and

[b] The CORA model is a computerized expert advisor used to select remedial actions for Superfund hazardous waste sites and estimate their costs. It also may be used for RCRA or other corrective actions. The model may be used for site-specific estimates and for agency programming, budgeting and planning. DOD uses CORA *primarily for programming and budgeting purposes*. The model analyzes a site based on user input of site characteristics such as types of wastes and media, selects treatment technologies from a database of 42 technologies, and estimates implementation costs. EPA has estimated that the cost system is accurate within -30% to +50%.

Exhibit 6-4: Typical Volume of Contaminated Soil for Selected Site Categories

Site Category	No. of Sites[a]	Cubic Yards Per Site	Total Cubic Yards[b]	Common Waste Present
Aboveground Storage Tanks	133	5,400	718,200	Petroleum Waste, VOCs
Burn Area				VOCs, PCBs
Large	56	7,300	408,800	
Small	65	NA	NA	
Contaminated Sediment				Oil, Grease, Phenols, Toluene
Large	22	4,400	96,800	
Small	87	NA	NA	
Disposal Pit/Dry Well	340	6,500	2,210,000	PCBs, Chlorobenzene, Vinyl Chloride
Fire/Crash Training Area				Oil, Grease
Large	200	5,600	1,120,000	
Small	87	700	60,900	
Spill Area	585	1,600	936,000	PCBs
Storage Area				Acetone, Pesticides, Arsenic
Large	94	9,500	893,000	
Small	895	1,400	1,253,000	
Underground Storage Tanks	1,588	1,000	1,588,000	VOCs
Waste Treatment Plant				Heavy Metals
Large	80	8,500	680,000	
Small	21	1,020	21,000	

Notes:
[a] From Exhibit 6-2.
[b] Number of sites times the average cubic yards per site.

Source: DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate*, September 1991.

maintenance (O&M) will cost $4 billion; PAs, SIs, and RI/FSs will cost $1.5 billion; and IRP administration will cost $2.1 billion. Other items, such as third party site expenditures, reimbursements to states for technical support services, and research, development, and demonstrations (RD&D), will cost about $1.4 billion. The total estimated cost for all IRP activities over the next 20 years is $24.5 billion.

6.5 Market Entry Considerations

Although policy is determined centrally by the Deputy Assistant Secretary of Defense (Environment), each service is responsible for investigating and restoring its own installations; and each uses its own approach to this work. Virtually all DOD site assessment and remedial action work is done through contractors. Generally, there are two groups of contractors: those that work on site assessments and investigation (PA through RI/FS) and those that do RA. Contractors that work on PAs through RI/FSs seldom work on RD/RAs. Vendors interested in innovative technologies should ensure that their technologies are considered at the earlier stages of site investigation and assessment. Appendix B lists DOD points of contact for each service.

Exhibit 6-5: Total Cost of Remedial Action ($000)

Site Category[a]	No. of Sites to be Remediated	Army RA Costs[b]	Navy RA Costs[b]	Air Force RA Costs[b]	DLA RA Costs[b]	FUDS Costs[b]	Total[b]
Aboveground Storage Tank[c]	133	$212,250	$42,550	$78,000	$0	NA[c]	$332,800[c]
Large Burn Area	56	$234,720	$0	$0	$33,408	$0	$268,128
Small Burn Area	65	$0	$64,672	$39,936	$0	$0	$104,608
Contaminated Ground Water	49	$132,600	$47,073	$61,047	$10,251	$0	$250,971
Contaminated Sediment							
Large	22	$0	$79,200	$0	$0	$0	$79,200
Small	87	$7,020	$0	$141,372	$6,498	$0	$154,890
Contaminated Building	211	$367,200	$52,000	$2,000	$0	$0	$421,200
Disposal Pit/Dry Well	340	$159,840	$338,184	$235,200	$81,792	$0	$815,016
Explosive/Ordnance Disposal Area	183	$111,300	$80,080	$35,280	$0	$59,040	$285,700
Fire/Crash Training Area							
Large	200	$0	$0	$438,346	$2,200	$0	$440,546
Small	87	$9,540	$42,504	$0	$0	$0	$52,044
Large Landfill	404	$959,640	$44,880	$765,415	$8,712	$0	$1,778,647
Small Landfill	343	$0	$248,625	$260,937	$3,780	$0	$513,342
POL Line	43	$0	$21,528	$82,128	$0	$0	$103,656

Notes:

[a] The definitions of site categories appear in Appendix A, Exhibit A-10.

[b] The remedial action (RA) costs include activities such as removals, treatment, or disposal, but do not include long-term operations and maintenance (O&M) costs for activities such as ground water monitoring and replacement of a soil cap, or remedial design costs. The anticipated O&M costs, in thousands of 1991 dollars, are $4,096,277 ($1,734,467 for the Army; $632,246 for the Navy; $1,116,384 for the Air Force; $46,359 for the DLA; and $566,821 for FUDS). The anticipated remedial design costs are $1,389,286 ($641,623 for the Army; $203,105 for the Navy; $375,052 for the Air Force; $32,295 for the DLA; and $137,311 for FUDS).

[c] The estimate for FUDS storage tanks includes both underground and aboveground tanks.

Source: DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate*, September 1991.

Exhibit 6-5: Total Cost of Remedial Action (continued) ($000)

Site Category[a]	No. of Sites to be Remediated	Army RA Costs[b]	Navy RA Costs[b]	Air Force RA Costs[b]	DLA RA Costs[b]	FUDS Costs[b]	Total[b]
Spill Area	585	$65,160	$84,693	$198,806	$2,418	$0	$351,077
Storage Area							
Large	94	$570,000	$0	$0	$143,260	$0	$713,260
Small	895	$669,600	$116,480	$109,140	$0	$0	$895,220
Surface Disposal Area	464	$188,550	$316,389	$190,082	$0	$0	$695,021
Surface Impoundment/Lagoon	289	$572,400	$104,400	$183,750	$5,940	$0	$866,490
Underground Storage Tank Area[c]	1588	$609,420	$79,254	$373,327	$4,214	$165,248[c]	$1,231,463[c]
Waste Line	36	$17,820	$43,560	$17,688	$0	$0	$79,068
Waste Treatment Plant							
Large	80	$243,780	$0	$27,132	$0	$0	$270,912
Small	21	$0	$9,072	$5,586	$0	$0	$14,658
None of the Above	510	$878,557	$87,120	$267,541	$0	$0	$1,233,218
Hazardous and Toxic Waste	531	NA	NA	NA	NA	$1,061,760	$1,061,760
Totals, 1989 Dollars[b]	7,313	$6,009,397	$1,902,264	$3,512,712	$302,473	$1,286,048	$13,012,894
Totals, 1991 Dollars[b]		$6,416,233	$2,031,047	$3,750,523	$322,950	$1,373,113	$13,893,866

Notes:

[a] The definitions of site categories appear in Appendix A, Exhibit A-10.

[b] The remedial action (RA) costs include activities such as removals, treatment, or disposal, but do not include long-term operations and maintenance (O&M) costs for activities such as ground water monitoring *and replacement* of a soil cap, *nor* do they include remedial design costs. The anticipated O&M costs, in thousands of 1991 dollars, are $4,096,277 ($1,734,467 for the Army; $632,246 for the Navy; $1,116,384 for the Air Force; $46,359 for the DLA; and $566,821 for FUDS). The anticipated remedial design costs are $1,389,286 ($641,623 for the Army; $203,105 for the Navy; $375,052 for the Air Force; $32,295 for the DLA; and $137,311 for FUDS).

[c] The estimate for FUDS storage tanks includes both underground and aboveground tanks.

Source: DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate,* September 1991.

The management of the Army IRP is the responsibility of the U.S. Army Environmental Center (USAEC), formerly the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), which was part of the Army Corps of Engineers (USACE). USACE schedules all activities and does studies for PAs, SIs, and RIs/FSs, through more than two dozen contractors. RD/RA is done by the USACE under the direction of USAEC. In the past, most of the design work has been done by the USACE's Missouri River Division (MRD), although some work is also done by other USACE divisions and districts.

The management of the Navy IRP is the responsibility of the Navy Facilities Engineering Command (NAVFAC), which reports to the Assistant Secretary of the Navy for Installations and Environment. Day-to-day work of the IRP is run by ten field divisions that operate within distinct geographical boundaries. Each division has a contract, which is issued through NAVFAC (known as the Comprehensive Long-Term Environmental Action Navy contract—CLEAN). These contracts are primarily for work relating to the PA through the RD.

The Air Force IRP is decentralized. It is executed by the Air Force Major Commands. Each may use specialized technical support from environmental contractors. Contractors are accessed through pre-established task-order contracts administered five contract service centers, individual contracts let by the commands themselves, or individual installations. Although much of the Air Force's restoration work is currently being conducted by the USACE, the Air Force plans to issue its own contracts for this work.

The Defense Logistics Agency's sites are managed by the Huntsville, Alabama, district of the USACE.

6.6 Remedial Technologies

Information on the technologies being used at DOD sites is limited. DOD and EPA have jointly compiled a partial list of innovative technologies selected or used at DOD sites. Bioremediation has been selected for 11 DOD sites for VOCs and PAHs; soil vapor extraction has been selected at 10 DOD sites for VOCs, PAHs, and gasoline; soil washing has been selected at two sites for PCBs and metals; and soil flushing and *in situ* vitrification are each to be used at one site. A list of these DOD sites appears in EPA's *Innovative Treatment Technologies: Semi-Annual Status Report.*[4]

The DOD spends $13.5 million annually on RD&D, primarily to demonstrate promising technologies. The Air Force has placed special emphasis on bioventing, which it is demonstrating at over 100 sites across the country. Examples of other technologies demonstrated include: *in situ* and *ex situ* vapor extraction, *in situ* soil venting, *in situ* bioventing, *in situ* bioremediation, *ex situ* bioremediation of petroleum products in soil and ground water, chemical detoxification of chlorinated aromatic compounds, *in situ* carbon regeneration, incineration of explosives-contaminated soil, infrared thermal destruction, low temperature thermal stripping, mobile rotary kiln incineration of soil, thermal destruction, radio frequency thermal soil decontamination, stabilization/solidification, and compacting explosives contaminated soil. DOD work on these and other technologies are summarized biannually in a reference of current IRP and hazardous waste treatment technologies. The document provides a brief summary of each project and a contact for further technical information.[5] Other information on DOD demonstration projects is available in a publication from the Federal Remediation Technology Roundtable.[6]

6.7 References

1. U.S. Department of Defense, Office of the Assistant Secretary of Defense (Environment), "Installation Restoration Program Cost Estimate," September 1991.

2. U.S. Department of Defense, "Defense Environmental Restoration Program: Annual Report to Congress For Fiscal Year 1991," February 1992.

3. Hunter, P.M., "The Installation Restoration Program Information Management System (IRPIMS)^{TM} and an Overview of the Air Force Hazardous Waste Investigations," *Military Activities*, December 1990.

4. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation Office, "Innovative Treatment Technologies: Semi-Annual Status Report," EPA/542/R-92/011, October 1992.

5. U.S. Department of Defense, U.S. Army Toxics and Hazardous Materials Agency, Army Corps of Engineers, "Installation Restoration and Hazardous Waste Control Technologies," CETHA-TS-CR-90067, Aberdeen Proving Ground, MD, November 1992.

6. U.S. Environmental Protection Agency, *et al.*, "Synopses of Federal Demonstrations of Innovative Site Remediation Technologies," Second Edition, prepared by the member agencies of the Federal Remediation Technologies Roundtable, EPA/542/B-92/003, August 1992.

CHAPTER 7
DEMAND FOR REMEDIATION OF DEPARTMENT OF ENERGY SITES

One of the most serious and costly environmental remediation tasks facing the federal government is the cleanup and restoration of more than 100 major installations and other locations that are the responsibility of the U.S. Department of Energy (DOE). Environmental problems at DOE installations began in the 1940s with the Manhattan Project and continued for more than 40 years while the government developed its nuclear complex. Research, development, and production of nuclear weapons and reactors, resulted in the generation and disposal of large quantities of radioactive and non-radioactive wastes, which have contaminated a number of large "sites" and many smaller ones.

The scope of the remediation needed is still being evaluated. DOE is in the process of completing a major "programmatic environmental impact statement" (PEIS). The PEIS, which is expected to be completed during fiscal year 1993, will document the environmental cleanup and restoration needs at DOE installations to the extent possible.

DOE is committed to cleaning up contamination and bringing all its installations into environmental compliance by the year 2019.[1] Realizing this goal will create enormous opportunity for firms that provide remediation services.

7.1 Program Description

DOE's environmental programs are managed by its Office of Environmental Restoration and Waste Management and fall into two broad categories: Waste Operations and Environmental Restoration. As its name implies, *Waste Operations* is concerned with the treatment, storage, and disposal of wastes generated from DOE's ongoing operations. Included in this category are DOE's Corrective Activities, which are intended to bring operating installations into compliance with applicable federal, state, and local health, safety, and environmental regulations.

Environmental Restoration is the primary focus of this chapter. This program was developed to assess and clean up installations and "facilities"—such as reactors, laboratories, equipment, buildings, pipelines, waste treatment systems, and storage tanks—contaminated with radioactive, hazardous, and mixed waste stemming from past operations of DOE's nuclear programs. This program includes corrective actions under the Resource Conservation and Recovery Act (RCRA), which are necessary for sites at about one-quarter of DOE's installations. All sites requiring cleanup under RCRA are addressed in Chapter 4 of this report.

Environmental Restoration has two subprograms: *Decontamination and Decommissioning*, which focuses on contaminated equipment, buildings, and other facilities; and *Remedial Actions*, which focuses primarily on sites with contaminated soil and water.

7.1.1 Decontamination and Decommissioning (D&D)

Decontamination and Decommissioning (D&D) is DOE's program to manage government-owned, retired facilities that were used for early nuclear energy research and defense programs. DOE is responsible for managing these surplus facilities to protect the public health and environment from radioactive or hazardous materials that may be present until the facilities can be decontaminated and entombed, dismantled and removed, or converted for non-nuclear use. About 500 such facilities are currently slated for D&D by 2019, but as many as 1,000 facilities ultimately may require D&D.[1]

7.1.2 Remedial Actions Program

About 90% of DOE's installations require environmental work under the Remedial Actions Program. These installations vary widely in size. For example, the Laboratory for Energy-Related

Health Research in Davis, California, occupies 15 acres, while Hanford Reservation in the southeastern part of Washington covers 560 square miles. The Remedial Actions Program includes assessment, characterization, remediation, and closure activities. Assessment and characterization activities are still in progress at most installations. Much of the work will continue for years.

Thirty-five of the installations currently requiring remediation by DOE are being addressed under two specialized subsets of the Remedial Actions Program: the Uranium Mill Tailings Remedial Action (UMTRA) Project and the Formerly Utilized Sites Remedial Action Program (FUSRAP).[2]

The UMTRA Project provides for stabilizing and controlling uranium mill tailings at inactive mills. The tailings resulted from the production of uranium between the early 1950s and the early 1970s. In addition to the primary UMTRA sites, many private residential and commercial properties are being remediated under the project. These "vicinity" properties are contaminated because tailings were used as fill for construction and landscaping, or were carried by the wind to open areas. DOE is working to complete surface remediation work at all the remaining sites by 1998 when Congressional authorization for the project expires. In addition, ground-water restoration is required at some sites and is expected to begin in 1998 and continue through 2014.

FUSRAP involves the cleanup or control of sites owned or leased by DOE or other government agencies as well as privately owned commercial and residential property—where there is residual radioactive material from the early years of the nation's atomic energy program. DOE anticipates that remediation activities under FUSRAP will continue for more than 25 years.

7.2 Factors Affecting Demand for DOE Site Cleanup

The following factors affect the demand for remediation of DOE installations.

- Cleanup and restoration work at most DOE installations is in the early stages. The nature and magnitude of the problem at many sites is still only partially known.
- DOE does not expect to clean up all sites and bring all of its installations into environmental compliance until at least 2019. This provides a 30-year "window of opportunity" for vendors of remediation technologies and services. However, sites with arid soils that are contaminated with volatile organic compounds (VOCs) are a high priority. DOE expects to complete Records of Decision (RODs) for the majority of these sites by 1995.[3]
- The 30-year estimate to remediate all DOE sites could be lengthened or shortened depending on the funds appropriated by Congress for DOE programs. Cleanup schedules are heavily dependent on available funds.
- Just over 6% of the annual budget of DOE's Office of Environmental Restoration and Waste Management is used to fund technology development activities. This amounts to an estimated $2.2 billion over the next five years (fiscal years 1994-1998).[3]
- As with DOD, cleanup requirements at DOE sites are extremely sensitive to changes in a wide variety of environmental statutes and regulations. Remedial, decontamination, decommissioning, and waste management and compliance-related corrective activities overlap at many installations. The requirements of a variety of federal laws simultaneously impact decision making. In addition to EPA regulations, these statutes include the Atomic Energy Act and the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRA). Vendors in this market should keep up to date on regulatory and legislative developments of concern to DOE remediation efforts.
- DOE gives top priority to cleanup activities necessary to prevent near-term adverse impacts to workers, the public, or the environment and to activities required to meet the terms of agreements between DOE and local, state, or federal agencies.

7.3 Number and Characteristics of Sites

DOE is responsible for 110 locations in 33 states and Puerto Rico under its Remedial Actions and Decontamination and Decommissioning Programs.[3]

Assessment and characterization activities have yet to be completed at nearly two-thirds of the installations, including most of the major installations such as Rocky Flats, Colorado, Oak Ridge Reservation, Tennessee, Savannah River, South Carolina, and Hanford Reservation, Washington.

Many DOE locations contain more than one "site" or area of contamination, and each area may require different remedies. DOE estimates that about 4,000 contaminated sites, covering more than 26,000 acres at DOE installations and non-DOE locations, require some remediation. The number of sites grows as assessment and characterization activities continue.[4]

Twenty-three sites at 16 DOE locations are on the Superfund National Priorities List (NPL). DOE has lead responsibility in the cleanup of these sites. DOE also is involved in the remediation of four other NPL sites—Maxey Flats, Kentucky; Shpack Landfill, Massachusetts; South Valley Site, New Mexico; and Monticello Uranium Mill, Utah. These are EPA-lead sites for which DOE shares financial responsibility with other responsible parties.

Exhibit 7-1 lists the 62 installations and other locations at which assessment and characterization activities are in progress or have yet to be initiated under DOE's Remedial Actions Program, including 15 of the 16 NPL sites. These installations and other locations represent potential areas for applications of innovative technology. The exhibit includes only the sites for which DOE has lead-agency responsibility. It identifies contaminated matrices of concern, examples of contaminants reported, estimated volumes of contaminated soil, and estimated near-term (fiscal years 1994-1998) remedial action costs. Appendix A, Exhibit A-12 provides similar information where remedial work is already in progress or has been completed for DOE-lead installations and other locations, including one NPL site. Data for these tables were compiled from reports published by DOE in 1991 and 1993 and interviews in 1992 with personnel in DOE Operations Offices throughout the country and selected DOE contractors.

Information about the nature of contaminants at many of these installations is incomplete. In some cases, they are unique to nuclear production and include high- and low-level radioactive wastes, explosives, and pyrophorics. In other cases, contaminants such as inorganic chemicals, fuels, solvents, halogenated organics, and heavy metals are similar to those generated in a variety of industrial processes.[4] Mixed waste, contaminated with radioactive and hazardous constituents, also is a significant problem at many installations and sites.

At many DOE installations, contaminated soil is the major problem. Some general estimates of soil quantities are available for 22 of the installations. DOE estimates that just over 6 million cubic yards of mill tailings will be remediated under the UMTRA project. Another 1.6 million cubic yards of soil will be remediated under FUSRAP. The total quantity of soil to be remediated at all DOE installations has not been determined. Exhibit 7-1 provides available site estimates.

7.4 Estimated Dollar Value of Site Cleanup

Three major factors affect DOE's ability to accurately estimate what it will cost to complete its 30-year cleanup effort.

- The extent of the problems at many installations is not known;
- Federal budget goals are redefined each year, and Congressional appropriations priorities change; and
- Future development of innovative technologies could offset some of the costs.

Because of these factors, DOE has not generated an overall estimate of the 30-year total cleanup cost. The Agency's *Environmental Restoration and Waste Management Five-Year Plan*, updated each year, provides the most realistic estimate of intended near-term investment in remediation services and technology development. Total funding planned for DOE cleanup and restoration activities—including assessment/characterization, cleanup, and closure and monitoring—for fiscal years 1994 through 1998 is $12.3 billion. Another $2.2 billion is earmarked for technology development activities.[3] Some estimates place the final cost of cleaning up DOE's weapons complex at over $200 billion.[5][6]

7.5 Market Entry Considerations

Contractors perform virtually all cleanup and restoration work at DOE installations. DOE issues

Exhibit 7-1: DOE Installations/Sites To Be Remediated[a]

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (millions)
AK	Amchitka Island	Not Initiated					
CA	Energy Technology Engineering Center	Includes D&D	A/C	Soil, Ground Water	Low-level Radioactive Waste	Unknown	$25.7
	Laboratory for Energy-Related Health Research	Includes D&D	A/C	Soil, Ground Water, Masonry, Metals, Sludge	Nitrate, Sr-90, Ra-226, VOCs, C-14, Chlordane, Cr, H-3	20,000	$27.5
	Lawrence Berkeley Laboratory		A/C	Soil, Ground Water	Unknown	Unknown	$24.2
	Lawrence Livermore Laboratory[b]	On NPL	A/C	Soil, Ground Water	Gasoline, Explosives, VOCs		$353.9
	Sandia National Laboratory - Livermore		A/C	Soil, Buried Material	Diesel Fuel Oil, Benzene, Pb	Unknown	$18.5
	Stanford Linear Accelerator Center		A/C	Soil, Ground Water	PCBs		$9.2
CO	Grand Junction Project Office[c]	UMTRA, On NPL	A/C	Soil	Radon, Radon "Daughters"		$154.9
	Maybell	UMTRA	A/C	Soil, Ground Water	Radon, Radon "Daughters"	3.3 million	[d]
	Naturita	UMTRA	A/C	Soil, Ground Water	Radon, Radon "Daughters"	575,000	[d]

Exhibit 7-1: Continued

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (million)
CO	Rio Blanco	Not initiated					
	Rocky Flats Plant	On NPL	A/C	Soil, Ground Water, Surface Water, Sludge	Low-level Mixed Wastes, VOCs,	Unknown	$1,098.6
	Rullison	Not initiated					
	Slick Rock	UMTRA	A/C	Soil, Ground Water	Radon, Radon "Daughters"	1.3 million	d
CT	Seymour Specialty Wire	FUSRAP	A/C	Masonry, Metals			e
FL	Pinellas Plant		A/C	Soil, Ground Water	Oil, Iron, Low-level Wastes	Unknown	$31.2
HI	Kauai Test Facility		A/C	Unknown	Unknown	Unknown	f
IA	Ames Laboratory		A/C	Soil, Buried Material	Diesel Fuel, Chemical Wastes	Unknown	$21.6[g]
ID	Argonne National Laboratory-West	Includes D&D	A/C	Soil, Masonry	PCBs, Mixed Waste	Unknown	$9.6
	Idaho Chemical Processing Plant		A/C	Soil	PCBs	Unknown	h
	Idaho National Engineering Laboratory	Includes D&D, On NPL	A/C	Soil, Ground Water, Sediment, Masonry	VOCs, Heavy Metals	Unknown	$523.2

Exhibit 7-1: Continued

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (million)
IL	Argonne National Laboratory-East	Includes D&D	A/C	Soil, Ground Water, Sediment, Masonry, Sludge	Low-level Radioactive Waste, Metals, Organics, Mixed Wastes, Inorganics	Unknown	$66.1
KY	Paducah Gaseous Diffusion Plant		A/C	Soil, Ground Water, Sediment	PCBs, VOCs	Unknown	$170.7
MD	W.R. Grace & Company	FUSRAP	A/C	Soil	U, Pb, Th, Ra, PCBs	36,000	e
MI	General Motors	FUSRAP	A/C	Soil, Masonry	U-238	200	e
MO	Kansas City Plant		A/C	Soil, Ground Water	PCBs, Chlorinated Solvents	Unknown	$57.9
	Mallinckrodt, Inc. (St. Louis-Downtown)	FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	246,000	e
	St. Louis Airport Site	On NPL, FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	250,000	e
	St. Louis Airport Storage Vicinity Properties	On NPL, FUSRAP	A/C	Soil	U, Ra, Pb, Th, PCBs	190,000	e
	Weldon Spring	On NPL	A/C	Soil, Ground Water, Masonry	U, Th, Chemical Waste, VOCs, SVOCs, Explosives	590,000	$302.7
MS	Tatum Dome		A/C	Soil, Ground Water		Unknown	$7.4[i]

Exhibit 7-1: Continued

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (million)
ND	Belfield	UMTRA	A/C	Soil	Radon, Radon "Daughters"	58,000	d
	Bowman	UMTRA	A/C	Soil	Radon, Radon "Daughters"	128,400	d
NJ	DuPont & Company	FUSRAP	A/C	Soil, Masonry	Th, U, Ra, Pb, PCBs	8,270	e
	Maywood	On NPL, FUSRAP	A/C	Soil, Masonry	Th, U, Ra, Pb, PCBs	242,670	e
	New Brunswick Laboratory	FUSRAP	A/C	Soil, Masonry	Am, Pu, U, Ra	4,500	e
	Princeton Plasma Physics Laboratory		A/C	Soil, Ground Water	Unknown	Unknown	$21.6[g]
	Wayne/Pequannock	On NPL, FUSRAP	A/C	Soil, Masonry	Th, U, Ra, Pb, PCBs	109,000	e
NM	Gassbuggy Site	Not initiated					
	Gnome-Coach Site	Not initiated					
	Inhalation Toxicology Research Institute		A/C	Soil, Ground Water	Diesel Oil, Nitrate, Low-level Radioactive Waste	Unknown	$9.5
	Los Alamos National Laboratory	Includes D&D	A/C	Soil, Sediment, Buried Material	Low-level Radioactive Waste, VOCs, Metals, High Explosives	Unknown	$563.7

Exhibit 7-1: Continued

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (million)
NM	Sandia National Laboratory - Albuquerque		A/C	Soil, Ground Water, Buried Material	Chemical Waste, VOCs	Unknown	$187.9
NV	Central Nevada Test Site	Not Initiated					
	Nevada Test Site	Includes D&D	A/C	Soil, Ground Water	Radionuclides, Heavy Metals, VOCs, Caustics, Acids	Unknown	$229.1
	Shoal Site	Not Initiated					
	Tonopah Test Range		A/C	Soil, Ground Water	Radionuclides, Heavy Metals	Unknown	f
NY	Ashland Oil Co. #1	FUSRAP	A/C	Soil	U, Ra, Th, Pb, PCBs	84,000	e
	Ashland Oil Co. #2	FUSRAP	A/C	Soil	U, Ra, Th, Pb, PCBs	19,400	e
	Brookhaven National Laboratory	On NPL	A/C	Soil, Ground Water, Air, Sediment, Surface Water			$94.2
	Colonie Interim Storage	FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	14,200	e
	Linde Air Products	FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	26,800	e
	Niagara Falls Storage Site	FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	255,000	e
	Seaway Industrial Park	FUSRAP	A/C	Soil, Masonry	U, Ra, Th, Pb, PCBs	117,000	e

Exhibit 7-1: Continued

State	Installation/Site	Program Information	Status	Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Vol. To Be Remediated (Cu.Yards)	Est. Cost FY 94-98 (million)
OH	Fernald Environmental Management Project	Includes D&D, On NPL	A/C	Soil, Ground Water, Masonry	Low-level Radioactive Waste, Pyrophorics, VOCs	Unknown	$2,067.7
	Mound Plant	Includes D&D, On NPL	A/C	Soil, Ground Water, Masonry	Radioactive Waste	Unknown	$214.7
	Portsmouth Gaseous Diffusion Plant		A/C	Soil, Ground Water, Masonry	Technetium-99, TCE, PCBs, VOCs	Unknown	$163.3
PR	Center for Environmental Research	Not initiated					
SC	Savannah River Site	On NPL	A/C	Ground Water, Buried Material	VOCs	Unknown	$441.9
TN	Oak Ridge Reservation[j]	Includes D&D, On NPL	A/C	Soil, Ground Water, Masonry Sludge, Surface Water	Diesel Fuel Products, VOCs, U, Sr-90, Nitrate, Mercury, Nickel, Technetium	Unknown	$2,091.3
TX	Pantex Plant		A/C	Soil, Ground Water, Buried Material	VOCs, Metals, Explosives, PCBs, Dioxins, Petroleum Waste	Unknown	$110.8
WA	Hanford Reservation[k]	Includes D&D, On NPL	A/C	Soil, Ground Water, Masonry	Nitrates, Heavy Metals, VOCs, PCBs	Unknown	$1,241.7

Exhibit 7-1: Continued

Definitions:

UMTRA:	Uranium Mill Tailings Remedial Action Project site
D&D:	Decontamination and Decommissioning Program site
NPL:	Listed on the Superfund National Priorities List
FUSRAP:	Formerly Utilized Site Remedial Action Program site
A/C:	Assessment and characterization activities continue at this installation/site, making it a potential market for technology developers and vendors.

Notes:

[a] Information in this table is a compilation of data from the following sources:
- •U.S. Department of Energy, 1993, Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998 (DOE/S-00097P *Vol I*).
- •U.S. Department of Energy, 1991, Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1993-1997 (DOE/S-0090P).
- •Telephone interviews with appropriate DOE Field Office personnel and contractors during 1992.
- •U.S. Department of Energy, 1991, Technology Needs Assessment Final Report (DOE/ID/12584-92 Vol. 1).
- •U.S. Department of Energy, 1991, Technology Needs Assessment Final Report: Appendices A-J (DOE/ID/12584-92 Vol. 2).
- •U.S. Department of Energy, Undated, Uranium Mill Tailings Remedial Action (brochure).
- •Jacobs Engineering Group, Inc., 1991, UMTRA Questions and Answers (fact sheet).
- •Jacobs Engineering Group, Inc., 1991. UMTRA Fact Sheet (fact sheets are specific to each UMTRA site).
- •Records of Decision signed for some DOE sites.
- •Bechtel National, Inc., 1991, Volume Register for FUSRAP and SFMP Sites.

[b] Lawrence Livermore Laboratory includes two sites on the National Priorities List: Main Site and Site 300.

[c] The Grand Junction Project Office is responsible for one site on the National Priorities List: Monticello Vicinity Properties. This office also administers DOE's financial obligations in connection with remediation of the Monticello Uranium Mill, an EPA-lead site also on the National Priorities List.

[d] DOE's total validated estimate for environmental restoration work at UMTRA sites and vicinity properties for fiscal years 1994-1998 is $250.0 million. Site-by-site estimates were not included in the agency's Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998 (DOE/S-00097P Vol I and Vol II).

[e] DOE's total validated estimate for environmental restoration work at FUSRAP sites for Fiscal Years 1994-1998 is $456.7 million. Site-by-site estimates were not included in the agency's Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998 (DOE/S-00097P Vol I and Vol II).

[f] Funding for this site is included in the allocation for Sandia National Laboratory-Albuquerque.

[g] This allocation includes funding for activities at Ames Laboratory, Fermi National Accelerator Laboratory (IL), and Princeton Plasma Physics Laboratory (NJ).

[h] Funding for this site is included in the allocation for Idaho National Engineering Laboratory.

[i] This allocation includes funding for activities related to the following sites at which remedial work has yet to begin: Amchitka Island (AK), Rio Blanco and Rullison (CO), Tatum Dome (MS), Gassbuggy and Gnome (NM), and Shoal and Central Nevada Test Site (NV).

[j] Oak Ridge Reservation includes four sites on the National Priorities List: Oak Ridge National Laboratory, the K-25 Site that includes the Oak Ridge Gaseous Diffusion Plant, the Y-12 Plant, and Oak Ridge Associated Universities.

[k] Hanford Reservation includes four sites on the National Priorities List: 100 Area, 200 Area, 300 Area, and 1100 Area.

"requests for proposals" and awards contracts on a competitive basis. DOE awards remedial action contracts on a site-by-site basis, and appropriate DOE Operations Offices, each of which is responsible for one or more installations, manage the projects. Operations offices are listed in Appendix B. Contracts related to the FUSRAP and UMTRA Programs, both of which include sites in many states, are managed through the Oak Ridge and Albuquerque Operations Offices, respectively.

DOE is currently evaluating an alternative contracting mechanism, Environmental Restoration Management Contractors (ERMCs), to manage environmental restoration activities at its various installations. If the concept is fully implemented, an ERMC would be responsible for day-to-day project management and also would have the option of performing the remedial investigation/feasibility study portions of the cleanup process. After a ROD is issued for a given site, the ERMC would subcontract the remaining work to companies with specialized expertise and technology. Pilot tests of the concept currently are underway at the Fernald and Hanford installations.

7.6 Remedial Technologies

Information on the innovative technologies being used at DOE installations is too limited to predict future technology use. The following are examples of applications known to EPA: soil vapor extraction with horizontal wells and ground water air sparging have been selected for use at a leaking solvent line at DOE's Savannah River installation to treat VOCs and PAHs; soil washing, followed by physical separation and acid extraction, has been selected for use at a waste pond containing radioactive contaminants at the Idaho National Engineering Laboratory (INEL); and acid extraction has been selected at another INEL waste pond with radioactive contaminants. These DOE sites are included in the EPA report *Innovative Treatment Technologies: Semi-Annual Status Report.*[7]

7.7 Research, Development, and Demonstrations

DOE recognizes that much of the cleanup and environmental restoration at its installations cannot be accomplished without new technological solutions. Thus, DOE cleanups provide an opportunity for developers of innovative technologies.

DOE's technology-related research and development activities center around its Integrated Demonstrations Program. Integrated Demonstrations are staged at sites that DOE considers representative of the types of cleanup problems—such as volatile organics in ground water or heavy metals in surface soils—that have been identified or are anticipated at other DOE sites. The demonstrations are designed to develop "cradle-to-grave" solutions. As such, they involve a group of technologies that address all phases of environmental restoration projects—characterization, assessment, remediation, and monitoring—allowing DOE to evaluate the performance of innovative treatment technologies individually or as a system.[8] DOE has adopted this approach to focus on cleanup as the endpoint of its technology development efforts and to ensure that new solutions are transferable to other DOE installations.

Soil-related and ground water-related integrated demonstrations are being conducted on four classes of problems:

- Contamination by VOCs in ground water and soil in non-arid areas (Savannah River Site, South Carolina);
- VOC contamination in ground water and soils in arid areas (Hanford Reservation, Washington);
- Plutonium contaminated surface soils (Nevada Test Site, Nevada); and
- Uranium contaminated surface soils (Feed Materials Production Center in Fernald, Ohio).

Demonstrations at the Savannah River Site have included a two-phase *in situ* biodegradation process for removing trichloroethylene (TCE) and perchloroethylene (PCE) from ground water and surface soils and an *in situ* air stripping process using horizontal wells to remediate, concurrently, soils and ground water containing VOCs.

At the Hanford Reservation, bench- and pilot-scale tests of an *in situ* biological treatment system that simultaneously removes nitrates and carbon tetrachloride from contaminated ground water have been conducted. An *in situ* vitrification process also has been used, with positive results, to immobilize heavy metals and radionuclides in contaminated soil in and below a large liquid waste disposal crib.

In addition to the technologies demonstrated as part of the Integrated Demonstration Program, DOE has sponsored demonstrations of other innovative technologies. These include an advanced oxidation process that uses ozone, ultraviolet radiation, and hydrogen peroxide for the treatment of ground water contaminated with TCE at DOE's Kansas City Plant; a vacuum-induced soil venting process to clean up gasoline in the unsaturated zone tested at DOE's Lawrence Livermore National Laboratory in California; a thermal process, dynamic underground stripping, to treat underground leaks of organics at the Livermore facility; a solar detoxification process also tested at Livermore; and an above-ground biological treatment for degrading TCE within a mixture of other solvents in ground water at the Oak Ridge Gaseous Diffusion Plant on DOE's Oak Ridge Reservation in Tennessee. A summary of these demonstrations is included in the *Synopses of Federal Demonstrations of Innovative Site Remediation Technologies, Second Edition.*[9]

DOE has set several objectives for its remedial technology research and development programs during fiscal years 1994-1998, including:

- Development of effective methods for treating and removing hazardous heavy metals including mercury from soils and ground water at Oak Ridge Reservation;
- Further field testing of *in situ* remediation technologies, such as bioremediation, electrokinetics, soil washing, air stripping, solvent extraction, and vitrification;
- Evaluation of the stimulation of indigenous microorganisms by methane injection and the cost-effectiveness of biotechnology treatment alternatives;
- Encouragement of further development of *in situ* resistive and radiofrequency heating methods for improving removal of solvents from clay; and
- Development and demonstration of bioremediation technologies, including bioremediation characterization wells for VOCs in arid soils.

DOE uses several mechanisms to invite the private sector to participate in its technology research and development programs. These include Program Research and Development Announcements (PRDAs), Cooperative Research and Development Agreements (CRDAs), and the Small Business Technology Integration Program.

A PRDA is used to solicit individual proposals for research and development projects. DOE issued its first PRDA in December 1991, for $10 million.[4] A second PRDA, of equal value, was issued in 1992. DOE intends to issue other PRDAs in the future.

CRDAs provide a vehicle through which government-sponsored laboratories and private companies can collaborate on mutually beneficial research. About a dozen CRDAs have been signed to date to support DOE environmental programs. For example, General Electric Research and Development Center, Schenectady, New York, and DOE's Oak Ridge National Laboratory signed a CRDA in 1991 to collaborate on development and testing of bioremediation as a means to clean up PCB contamination.[10]

DOE's Small Business Technology Integration Program identifies funding to support innovative technology development by small businesses. Proposals for work under the program are invited through an annual solicitation announcement. DOE issued its first solicitation announcement in 1992. Awards under the program provide $50,000 to $99,000 for the initial six-month phase, which involves evaluation of the feasibility of applied research concepts. Second-phase funding of up to $500,000 provides for 12 to 18 months of additional R&D, demonstration, and evaluation of the technology. The third phase of the project involves use of the technology for full-scale site remediation and is funded on a case-by-case basis.

DOE is planning to establish industry liaisons, who specialize in various technology areas, within its Office of Technology Development. These liaisons will communicate DOE program and technology needs and provide other information to facilitate private industry participation in DOE projects.[4]

Developers and vendors of innovative technologies interested in more information about DOE's technology development efforts—including the integrated demonstrations, PRDA solicitations, CRDA opportunities, and the small business program—may write to the Technology Integration Division, Mail Stop EM-52, U.S. Department of Energy, Washington, DC 20585.

7.8 References

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3. U.S. Department of Energy, "Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998," Vol. I, DOE/S-00097P, 1993.

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10. "GE Oak Ridge Lab To Cooperate On PCB Bioremediation Research," *HazTECH News*, October 3, 1991.

CHAPTER 8
DEMAND FOR REMEDIATION OF CONTAMINATED WASTE SITES MANAGED BY CIVILIAN FEDERAL AGENCIES, STATES, AND PRIVATE PARTIES

The market to remediate contaminated waste sites includes thousands of sites managed by civilian federal agencies, the states, and private parties. Civilian federal agencies include all federal agencies except for the Department of Defense and the Department of Energy. Each civilian federal agency is responsible for cleaning up contaminated waste sites on property owned or formerly owned by the agency. All sites that are not being cleaned up under the federal Superfund program, but still need attention, are deferred to state waste programs. Private parties are individuals or companies not affiliated with federal or state governments. These parties may undertake remedial action on their property without state or federal intervention.

Compared to the other market segments, the market for civilian federal agencies is relatively small. As of 1990, about 350 sites or facilities owned, formerly owned, or operated by 16 federal civilian agencies needed remediation. In 1990, to assess and clean up these sites, federal agencies requested about $1.1 billion for fiscal years 1991 to 1995.

The state market is substantially larger than that of the civilian federal agencies. Although EPA has determined that over 19,000 sites require some type of action beyond a preliminary assessment, the exact number of sites that will need remediation is still unknown. The cleanup of state sites is usually financed by responsible parties. To manage the cleanup of sites, many states have created their own program patterned after the federal Superfund program. Most of these programs include funds to clean up abandoned waste sites. At the end of 1991, the balance of state Superfunds was over $2.2 billion. Another indication of state efforts to clean up sites is the level of recent expenditures on hazardous waste remediation, which totalled over $400 million in 1991.

The size of the market for private party cleanups is difficult to define because little is known about this market. Few studies are available that identify either the number of private party sites that need to be cleaned up or how much money private parties plan to spend on assessment and hazardous waste remediation.

8.1 Demand for Cleanup of Sites Managed By Civilian Federal Agencies

As owner of one-third of the nation's land area, the federal government is liable for cleaning up hundreds of sites contaminated with hazardous chemicals and petroleum products. These sites include, among other types, research laboratories, maintenance facilities, landfills, and abandoned mines. All federal agencies with potentially contaminated sites have developed programs to clean up these sites.

8.1.1 Civilian Federal Agency Contaminated Site Programs

The federal government must comply in the same manner as private parties with the environmental regulations imposed by the Comprehensive Environmental Resource, Conservation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). These statutes make federal agencies liable for the cleanup of contaminated waste on property owned or formerly owned by federal agencies. Under the 1986 Superfund Amendments and Reauthorization Act (SARA), the federal government also may be responsible for cleaning up contaminated waste at sites where it lent money to the owners or has acquired property through foreclosure or other means. To meet these requirements, civilian federal agencies have established programs to assess potentially contaminated sites, including leaking underground storage tanks (USTs), and to clean them up if necessary. Most federal agencies have established central offices to manage these programs; however, some have adopted a decentralized approach by organizing their programs by function or geographical location.

Sixteen civilian agencies have identified at least one potentially contaminated waste site (Exhibit 8-1). Most of the information presented in this exhibit and this section is derived from the 1990 Congressional Budget Office (CBO) study, *Federal Liabilities Under Hazardous Waste Laws* and its supplemental report.[1][2]

8.1.2 Factors Affecting Demand for Civilian Federal Agency Site Cleanup

The primary factors influencing the market for remediation of civilian federal agency contaminated waste sites include: 1) the federal budget process; 2) potential federal liability stemming from loans and federal acquisition of property through foreclosure or other means; 3) future changes in federal and state environmental requirements; and 4) agency-specific programmatic requirements.

All federal agencies are constrained by budget considerations when planning for site remediation. Even though agencies may request funds for contaminated site management and remediation, Congress may not provide all of the necessary funding. In such cases, available funds will determine the rate and scope of remedial activities.

Potential federal liability at properties acquired through foreclosure or other means, the second factor, is defined in the final rule on *Lender Liability Under CERCLA*.[3] The Lender Liability Rule, issued in April 1992, clarifies government liability when federal regulatory, lending, and credit agencies, such as the Resolution Trust Corporation or the Small Business Administration (SBA), have "involuntarily acquired" contaminated property through foreclosure. In addition, the rule clarifies federal liability in cases where property has been acquired through other mechanisms, such as civil and criminal seizures and asset forfeitures.

In general, federal agencies that "involuntarily" acquire property are exempt from CERCLA liability. However, if a federal agency loans money to, and actively participates in the management of, organizations using or generating hazardous waste, it may be liable for remediating these sites if hazardous waste is spilled or improperly disposed. For example, federal credit agencies, such as the SBA, often provide loans and advice to businesses that use or generate hazardous materials. If SBA actively participated in management decisions and acquires the business through foreclosure, it may be liable for the cost of cleanup. Federal liability must be determined separately for each site acquired through foreclosure or other means. Data are not yet available on the number of sites for which civilian agencies will be liable under this new rule.

The third factor affecting the market is future changes in state and federal environmental regulations and standards. If future cleanup standards are more rigorous, the cost and effort to meet the standards could be much greater than currently anticipated. Conversely, if standards are reduced in the future, the remedial action market will be smaller.

Lastly, each agency has specific considerations that may affect cleanup capability and liability. Some of the considerations identified by CBO include:

- The Department of Agriculture (USDA) has not completely defined the scope of its contaminated waste site problem, especially for the Forest Service and Commodity Credit Corporation (CCC). The Forest Service has not assessed all of its abandoned mines, landfills, and dumps, and the CCC has not assessed its grain storage facilities. USDA cleanup liability may be extensive once all sites are identified.

- The Department of Commerce may incur cleanup liability for sites the Economic Development Administration (EDA) acquired through foreclosure and for sites operated by the War Productions Board (WPB). The WPB operated industrial properties during World War II and now may be partially liable for cleanup at these sites. EDA and the International Trade Administration have foreclosed on over 120 properties where wastes may have been generated and disposed on site. Under the Lender Liability Rule, Commerce may be partially responsible for cleanup of some sites.

- The General Services Administration (GSA) may be responsible for cleanup costs at properties it, or its predecessor agency, the War Assets Administration (WAA), sold in the past.

Exhibit 8-1: Summary of Types of Federal Agency Contaminated Waste Sites

Department of Agriculture	
Forest Service	➠ Abandoned mining sites—mine tailings were typically disposed on-site in unlined pits. ➠ Sanitary landfills and aboveground dumps—hazardous waste may have been disposed at Forest Service landfills. ➠ Wood preservation sites and three laboratories. ➠ Uninvestigated sites—117 sites needed to be investigated for contamination.
Agricultural Research Service	➠ Research laboratories—hazardous chemicals were used and disposed on-site in dry wells, surface impoundments, septic tanks, and other areas.
Commodity Credit Corporation (CCC)	➠ Grain storage facilities—carbon tetrachloride and other fumigants were applied to protect grain stored in the facilities. The CCC has not assessed most of the 2,000 sites it once operated. One site is on the NPL.
Farmers Home Administration	➠ Farms acquired through foreclosure—pesticides and other hazardous chemicals may have been disposed of on the land. Five farms needing cleanup have been identified.
Department of Commerce	➠ Research laboratories operated by the National Oceanographic and Atmospheric Administration. ➠ Properties acquired through foreclosure by the Economic Development Administration—industrial solvents and other wastes were generated from production activities at steel mills, iron foundries, leather tanneries, furniture manufacturers, and other heavy industries.
Environmental Protection Agency (EPA)	➠ EPA laboratories—hazardous wastes were either generated or stored for research purposes. EPA has determined that four facilities may require cleanup.
General Services Administration (GSA)	➠ GSA buildings and sites—although few locations have contamination problems, GSA may be liable for contaminated sites it has sold.
Department of the Interior	
Bureau of Land Management (BLM)	➠ Approximately 3,400 closed landfills may exist on BLM land—hazardous wastes may have been disposed at these BLM landfills. ➠ Abandoned mining operations—mine tailings were left on-site at many mines. ➠ Unauthorized hazardous waste sites—contaminants may have been illegally dumped on BLM land. The extent of the problem is unknown as BLM has not conducted a complete survey of its lands.
Bureau of Mines	➠ Research laboratories—hazardous materials were used, stored, or disposed on-site in landfills.
Bureau of Reclamation	➠ Reservoirs and drinking water supplies contaminated with agricultural runoff.
National Park Service	➠ Landfills and dumps inherited when the land was acquired. ➠ Abandoned mining operations—mine tailings were left on-site at many mines.
Fish and Wildlife Service	➠ Polluted sites—agricultural runoff of pesticides and fertilizers or upstream discharges of pollutants have contaminated some land. ➠ Inherited land previously used for industrial or defense purposes—industrial pollutants were disposed of on-site at inherited property. Fourteen of these sites are former Department of Defense properties.

Exhibit 8-1: Continued

Department of Justice	➠ Federal penitentiaries—hazardous materials were generated from industrial activities, including printing, woodworking, metalworking, and other activities. ➠ Illegal drug laboratories confiscated by the Drug Enforcement Agency—toxins were improperly stored or disposed at these drug laboratories.
National Aeronautics and Space Administration (NASA)	➠ Field installations, research laboratories, or industrial plants—hazardous materials were used, stored, or disposed on-site. Some NASA plants may have ground water contamination.
Small Business Administration	➠ Properties acquired through foreclosure—hazardous materials may have been improperly used or disposed on the property.
Tennessee Valley Authority	➠ Power generating plants and a fertilizer development laboratory—wastes, primarily consisting of fly ash and coal piles, have been disposed in on-site landfills.
Department of Transportation	
Federal Aviation Administration (FAA)	➠ FAA Technical Center—soil and ground water may be contaminated at 22 areas of the center. This site is on the NPL and assessment and remedial work is underway. ➠ Airfields—hazardous solvents and oils may have been spilled at airfields. As many as 53 Alaskan airfields may be contaminated.
U.S. Coast Guard	➠ Central storage areas for fuel and operation and maintenance facilities—solvents, fuel, or waste by-products leaked into the ground.
Department of Veterans Affairs	➠ Medical centers—hazardous and medical wastes were produced, stored, and incinerated.

Source: Congressional Budget Office, *Federal Agency Summaries: A Supplement to Federal Liabilities Under Hazardous Waste Laws,* May 1990.

The WAA sold industrial properties the government had acquired during World War II. GSA may be the last owner of record of many of these properties. Also, with the Department of Health and Human Services, GSA leased vacant public land to municipalities for sanitary landfills. About 30-40 landfills could be returned to GSA upon termination of the lease, leaving GSA potentially responsible for cleanup at these sites.

- The Department of Interior (DOI) may have extensive cleanup liability resulting from landfills and dumps on Park Service and Bureau of Land Management property. These sites have not been assessed. Also, many DOI sites are in isolated locations with a small local population. As the local population increases, these sites are more likely to become candidates for remedial action.

- The Department of Justice (DOJ) is liable for cleanup of illegal drug laboratories confiscated by the Drug Enforcement Agency (DEA). To satisfy CERCLA requirements, DOJ must clean up these sites prior to selling the property.

- The National Aeronautics and Space Administration (NASA) expects that ten of its facilities will need to be cleaned up. NASA predicts it will need major cleanup funds by fiscal year 1993.

- The Small Business Administration (SBA) may face liability associated with some properties acquired through foreclosure or at properties where it actively participated in management decisions of the company.

- The Resolution Trust Corporation (RTC) was created to acquire and sell insolvent thrift institutions. It has acquired a substantial number of properties that the thrifts gained through foreclosure. To sell these properties, site contamination must be remediated. The Lender Liability Rule may require the RTC to clean up some of these sites.

- The Department of Transportation (DOT) may need to clean up 53 airfield sites in Alaska. Although preliminary assessments have not been completed, DOT expects that most of these sites will require remedial action. Costs to clean up these sites may be high due to inclement weather and their remote location.

8.1.3 Number of Civilian Federal Agency Contaminated Waste Sites

Estimates of the number of federal civilian agency sites that will require some type of remedial action are derived primarily from the 1990 CBO report. Their principle source of information was the November 1988 *Federal Agency Hazardous Waste Compliance Docket*. The Docket, maintained by EPA, is a list of federal sites or facilities that use or store hazardous chemicals or that may be contaminated with hazardous waste. Federal agencies report facilities to the EPA in accordance with CERCLA and RCRA reporting requirements. The Docket is updated every six months. The February 1993 Docket lists a total of 925 civilian federal agency sites.[4]

The Docket does not specifically reflect the number of federal sites that will require remediation. It includes operating facilities that may not require remediation, such as RCRA facilities or large quantity generators. Also, once a site has been added to the Docket, it is not removed even after it is cleaned up. Furthermore, the Docket excludes sites that do not meet the CERCLA and RCRA reporting requirements, such as: former federal agency property that has been sold; private sites where the federal government may have contributed to site contamination; and facilities that generate small quantities of hazardous waste.

To better estimate the number of civilian federal sites that require remediation, CBO supplemented the Docket data with other sources of information from federal agencies. Based on this supplemental information, CBO eliminated 71 sites from the list of 515 sites on the November 1988 Docket, for a revised total of 444.[1] In addition, CBO identified 190 sites that were potentially contaminated but were not reported to the Docket because they did not meet the Docket reporting requirements. In total, CBO identified 634 federal sites potentially contaminated with hazardous substances. Of these sites, 349 may require some type of remedial action. CBO's estimates of the number of civilian federal agency sites with a possible contamination problem, and those sites that may require some type of remedial action, are shown in Exhibit 8-2.

Although the CBO study is the most comprehensive source of data on the potential federal hazardous waste problem, some factors limit its accuracy. First, some of the data presented in the study are almost three years old. Second, according to CBO, its estimate did not account for all potential sites because some federal agencies had not completed their inventory of potentially contaminated sites. Third, the CBO inventory does not include civilian federal agency sites that may need to be cleaned up under the Lender Liability Rule. The net effect of these limitations is that the estimated number of sites provided in this report is probably understated.

8.1.4 Estimated Dollar Value of Civilian Federal Agency's Site Cleanup

Developing accurate cost estimates for cleaning up contaminated waste sites managed by civilian federal agencies is difficult, primarily because detailed site information is not available. However, civilian federal agencies have estimated budgetary needs of approximately $1.1 billion for hazardous waste activities between 1991 and 1995.[2] These budgets are not exclusively for hazardous waste remediation activities; they also include compliance activities, waste management and operation, and preliminary waste site investigations. They also include costs associated with the cleanup of NPL and UST sites where a civilian federal agency has been designated a responsible party. The specific funding requests for each agency over this five-year period are presented in Exhibit 8-3.

Exhibit 8-2: Number of Federal Agency Sites Needing Cleanup

Agency	Amended 1988 Federal Docket[a]		Other Sites (Not on 1988 Docket)		All Potential Sites	
	Docket Sites	Sites Needing Cleanup	Other Sites	Sites Needing Cleanup	Total Sites	Sites Needing Cleanup
Department of Agriculture	39	25	52	48	91	73
Central Intelligence Agency	1	0	0	0	1	0
Department of Commerce	7	0	2	2	9	2
Environmental Protection Agency	14	4	1	1	15	5
General Services Administration	18	3	0	0	18	3
Health and Human Services	4	0	1	1	5	1
Department of the Interior	263	95	74	73	337	168
Department of Justice	2	0	7	7	9	7
National Aeronautics and Space Admin.	12	10	0	0	12	10
Postal Service	5	0	0	0	5	0
Small Business Administration	1	0	0	0	1	0
Tennessee Valley Authority	17	3	0	0	17	3
Department of Transportation	48	21	53	53	101	74
Department of the Treasury	2	0	0	0	2	0
Veterans Administration	11	3	0	0	11	3
Total	444	164	190	185	634	349

Notes:
[a] Numbers in this column are derived from the Congressional Budget Office (CBO), May 1990, study rather than from the November 1988, Docket update because CBO revised the Docket to reflect additional data obtained from conversations with federal agencies.

Sources: Congressional Budget Office, *Federal Liabilities Under Hazardous Waste Laws*, May 1990.
Congressional Budget Office, *Federal Agency Summaries: A Supplement to Federal Liabilities Under Hazardous Waste Laws*, May 1990.

According to the CBO report, each civilian federal agency has used these funds for a variety of purposes, depending upon its specific environmental priorities and problems. The majority of the Department of Agriculture's funds were earmarked for remedial actions. The Department of the Interior was anticipating that much of its budget will be needed to clean up sites where it is a responsible party, including existing NPL sites. The Tennessee Valley Authority planned to use its funds at one NPL site. The National Aeronautics and Space Administration expected to use most of its projected funding for site assessment at its 10 facilities and did not expect to start remedial

Exhibit 8-3: 1991-1995 Estimated Budget for Hazardous Waste Activities at Civilian Federal Agencies

Federal Civilian Agency	1991-1995 Estimated Budget for All Hazardous Waste Activities[a]
Department of Agriculture	\$80 million[b]
General Services Administration	\$5 million[b]
Department of the Interior	\$302 million[b]
Department of Justice	\$27 million[bc]
National Aeronautics and Space Administration	\$175 million[bc]
Postal Service	\$200 million[bc]
Tennessee Valley Authority	\$20 million[c]
Department of Transportation	\$260 million[b]

Notes:
[a] Estimated budgets are not exclusively for hazardous waste remediation activities. The budget estimates also include compliance activities, waste management and operation, and preliminary waste investigations.
[b] Source of information is from CBO's *Federal Liabilities Under Hazardous Waste Laws.*
[c] Source of information is from contacts with the federal agency.

Source: Congressional Budget Office, *Federal Liabilities Under Hazardous Waste Laws*, May 1990. Contacts with some of the federal agencies.

activity until the mid-1990s. The Postal Service and General Services Administration planned to allocate most of their funding for repair or replacement of underground storage tanks. The Department of Justice expected to use funds to clean up its seven federal prisons and some illegal drug laboratories. The bulk of funds required by the Department of Transportation were needed for compliance activities related to underground storage tanks. Some funds have been earmarked for remedial action projects at airports or other facilities owned by the Federal Aviation Administration.

8.2 Demand for Cleanup of State Hazardous Waste Sites

Numerous properties throughout the United States have been contaminated with hazardous chemicals. EPA, through the Superfund program, assesses many of these sites and cleans up the worst ones. Those sites eligible for Superfund cleanup are added to the National Priorities List (NPL). However, sites that do not qualify for the NPL and those sites not reported to EPA must be addressed by the states or responsible parties. Consequently, states have established hazardous waste programs to ensure potentially contaminated sites are assessed and cleaned up if necessary. Some state programs may also address UST cleanups, which were covered in Chapter 5 of this report.

Information on state programs, the number of sites, and status of those sites is derived from existing published information. Contacting individual states to obtain data was outside the scope of this study. The primary source of information is an EPA document, *An Analysis of State Superfund Programs: 50 State Study, 1991 Update.*[5] A second document, *Hazardous Waste Sites: State Cleanup Status and Its Implications for Federal Policy,*[6] also was used as a source of information. Although each document was developed for policy purposes, the information provided in the reports is useful for defining the state market for hazardous waste remediation.

According to these reports, states have identified over 60,000 sites that are known or suspected to be contaminated. The states estimate that almost 20,000 sites will require some action beyond a preliminary investigation, and clean up will require an investment of billions of dollars. Last year, state expenditures for hazardous waste activities were just under half a billion dollars. In addition, responsible parties (RPs) identified by the states financed the cleanup of about 60% of the non-NPL state sites in 1989.[6] The total expenditure by RPs to clean up these sites is unknown, but is probably equal to, if not more than, state expenditures.

8.2.1 State Hazardous Waste Programs

The primary source of information on states' hazardous waste programs is EPA's 1991 update of the *50 State Study*. This study describes each of the state's programs, including enabling legislation, enforcement provisions, staffing levels, funding, and other aspects of the programs. The legal and financial resources available to states indicate the extent of state involvement in and commitment to cleaning up contaminated sites.

Most of the states have enacted statutes patterned after CERCLA. These statutes typically include: provisions for emergency response and long-term remedial actions; cleanup funds or other mechanisms to finance remedial activities; enforcement authorities to compel RPs to perform or pay for cleanup activities; and staff to administer state-lead cleanups and monitor RP-lead cleanups. As of December 1991, 39 states had statutes providing full funding and enforcement capabilities. The remaining states relied on statutes with limited funding capabilities or on enforcement authority derived from statues not specifically intended for hazardous waste activities. All of the states, except Nebraska, have cleanup funds or accounts to finance some or all types of cleanup activities.

Many state statutes also authorize development of a priority list, inventory, or registry of state sites. Most states use their list to determine the order in which sites will be cleaned. By the end of 1991, 24 states were using priority lists while several others were using a registry or inventory.[5] For example, Texas has established a "State Registry" that ranks sites by priority. Maryland compiles both a "Disposal Site Registry" that lists ranked sites, including NPL sites, and a "Master List" of sites that have not been formally ranked, but have been evaluated for potential hazards.

One unique component of some state statutes lies with property transfer. These statutes are designed to ensure that real property being transferred between private parties does not pose health or environmental threats stemming from hazardous releases. In general, these laws require the owner or state to disclose that property was contaminated by hazardous materials either by recording a notice with the deed or by disclosing such information at the time of the property transaction. Some of these laws require the seller of the property to remediate the site prior to any transfer of property. As of December 1991, 18 states had some type of property transfer provisions in their laws or regulations.[5]

In 1991, staffing for the state programs varied from one person in Wyoming to about 800 staff positions in New Jersey.[5] Ten states had staffing levels exceeding 100 in 1991. Each of these states (California, Illinois, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, Washington, and Wisconsin) had a large number of confirmed or suspected contaminated sites. Three states (Florida, Minnesota, and Oregon) had staff levels between 51 and 100 people. The majority of states, a total of 28, had staff levels between 11 and 50, while 11 states had less than 10 staff positions for their hazardous waste program.

8.2.2 Factors Affecting Demand for States' Site Cleanup

The market for remediation of state hazardous waste sites is mostly dependent upon the commitment of states to establish and manage hazardous waste programs and the ability of states to finance cleanups or compel RPs to clean up sites. The level of remedial activity varies from state to state. For example, not all of the states with cleanup funds and enforcement authorities have been actively conducting cleanup programs. In 1991, only 29 of 39 such programs were actively performing removal or remedial actions at waste sites.[5] The 10 states with limited cleanup activities were inactive because their programs were recently established, understaffed, or underfunded. In addition, most states with inactive programs had a relatively low fund balance with which to clean up hazardous waste sites.

In states with mature, active programs, funding is the biggest factor affecting program activity.

Increases and decreases in state cleanup funds will affect the number and complexity of remedial actions undertaken by the states. State "Superfunds" may be impacted by economic and political conditions that influence state revenues. The recent recession has led to less cleanup activity in several states. For example, in 1991 New Jersey transferred $153.8 million from one of its cleanup funds to the state treasury to help balance the state budget.[5]

Except for the largest state programs, most state Superfunds possess limited money to finance cleanups. Consequently, in many states the cleanup of contaminated state sites is, in great part, dependent upon finding responsible parties willing to clean up the waste sites. According to the GAO report, responsible parties completely financed about 60% of state sites, while states completely financed only 24%, primarily through state Superfunds or general operating funds.[6]

Many years, if not decades, will be required to clean up contaminated state sites. GAO reported that six states estimated they would require five to ten years to complete their sites; eight estimated 11 to 20 years; nine estimated 21 to 50 years; and seven expected cleanup would take more than 50 years.[6] In short, remediation of state hazardous waste sites will continue well into the next century.

8.2.3 Number of State Hazardous Waste Sites

Published estimates of the number of state sites vary substantially, depending upon the source. The most current published estimate is from the 1991 Update of the *50 State Report*.[a] The *50 State Report* presents the results of a survey in which each state was asked to identify the total number of "Known and Suspected Sites" and the "Total Number of Sites Needing Attention." "Known and Suspected Sites" are those the states have identified that may be contaminated with hazardous chemicals. The category "Total Number of Sites Needing Attention" are known and suspected sites that have been evaluated, screened to some extent, and determined to require some further level of investigation or action. The *50 State Report* does not present estimates of the number of sites that definitely will require remedial action. Exhibit 8-4 presents each state's estimate for both categories of sites. The total number of known and suspected sites is 69,808. The total number of sites needing attention is 19,226. Neither category includes UST cleanups.

Aggregate information is not available that characterizes the types and quantities of contaminants found at state sites. However, some states with established, well-funded programs are able to produce this type of information. Many state environmental departments publish annual reports that include site-specific information about sites listed on state hazardous waste site registries or priority lists. For example, New York publishes a ten-volume report, *Inactive Hazardous Waste Disposal Sites in New York State—Annual Report*, and New Jersey issues an annual report, *Site Remediation Program Site Status Report*.[7][8] In addition, seven states maintain a database of known sites; however, the level of detail in the databases varies.[5] A national database of aggregate state data does not exist.

The types of contaminants present at state sites can be inferred from sites listed on CERCLIS, EPA's database of potentially contaminated sites. EPA has performed preliminary assessments at these sites to screen them for the federal NPL. The majority of these sites (those not listed on the NPL) are deferred to the states for action. CERCLIS data show that the most prevalent wastes at these sites are organic chemicals, metals, solvents, and oily waste.[9]

8.2.4 Estimated Dollar Value of States' Site Cleanup

Data are not available to estimate the aggregate dollar value of the market for cleaning up state sites. Most states rely extensively on RPs to clean

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[a] Other recent publications that provided estimates of the number of state sites include: EPA's *An Analysis of State Superfund Programs: 50 State Study*, the 1989 and 1990 versions; GAO's *Hazardous Waste Sites: State Cleanup Status and Its Implications for Federal Policy*; and a University of Tennessee at Knoxville publication, *State and Private Sector Cleanups*. See Appendix C, Bibliography, for a full citation of these documents. The estimates in these documents for known and suspected sites ranged from 50,560 to 62,792. Estimates for sites needing attention varied from 18,942 to 43,616.

Exhibit 8-4: Number of State Hazardous Waste Sites

States	Known & Suspected Sites[a]	Sites Needing Attention[b]	States	Known & Suspected Sites[a]	Sites Needing Attention[b]
Alabama	400	400	Montana	227	204*
Alaska	900	900*	Nebraska	334	38
Arizona	800+	500	Nevada	160	40
Arkansas	351	101	New Hampshire	400+	150
California	26,000	400	New Jersey	600[c]	600
Colorado	420	—	New Mexico	600	220
Connecticut	1,150	520*	New York	1,464	946
Delaware	250	70	North Carolina	925	672
Dist. of Columbia	0	0	North Dakota	59	3
Florida	980	708	Ohio	1,300	700
Georgia	753+	67	Oklahoma	30	—
Hawaii	140	—	Oregon	962	114
Idaho	164	164	Pennsylvania	2,685	1,067
Illinois	1,325	224	Puerto Rico	≈200	—
Indiana	1,500	39	Rhode Island	290	—
Iowa	454	155	South Carolina	425	88
Kansas	412	412	South Dakota	73	—
Kentucky	600	100*	Tennessee	1,000	161*
Louisiana	637	180*	Texas	>1,000	<500
Maine	373	160	Utah	210	195
Maryland	531	393	Vermont	959[d]	959[d]
Massachusetts	5,137	2,226*	Virginia	531	100
Michigan	≈4,300	2,844*	Washington	950	262*
Minnesota	447	178	West Virginia	431	—
Mississippi	599	170	Wisconsin	4,000	650
Missouri	1,250	600	Wyoming	120	86
			Total	69,808	19,266

Notes:

[a] "Known and Suspected" sites are those that states have identified as being potentially contaminated. Most of these sites will not require action beyond a preliminary assessment.

[b] "Sites Needing Attention" are those of the "Known and Suspected" list that have been evaluated and determined to require some level of action. Most of these sites will not require remedial action. Site numbers are derived from one of two categories from Table V-3 of the *50 State Report*: "Sites Identified as Needing Attention" or "Priority List or Registry." If a number was not provided in the "Sites Identified as Needing Attention" category, a number from "Priority List or Registry" was used. If numbers were provided in both categories, the most appropriate number was selected based on information provided in Chapter VI (State Summaries) of the *50 State Report*. Some numbers may have been adjusted to reflect the additional information. Adjusted numbers are noted with an asterisk (*).

[c] New Jersey has not completed an inventory of sites; however, it expects the inventory to number in the thousands. Thus, the number of "Known and Suspected Sites" is the same as the number listed in "Inventory or Registry."

[d] Since Vermont includes all contaminated sites in one list, the total of 959 includes petroleum and non-petroleum sites.

Source: U.S. EPA, Office of Emergency and Remedial Response, *An Analysis of State Superfund Programs: 50 State Study, 1991 Update*, December 1991.

up contaminated sites, and no data are available on projected RP costs. Information is available on annual state expenditures for hazardous waste activities and on balances of state Superfunds. Although these values probably represent a small portion of the total cost of remediating state sites, they indicate the current level of state hazardous waste activity.

Exhibit 8-5 provides the total 1991 expenditures for each state for hazardous waste activities and the state Superfund balance as of December 1991. In 1991, states spent or encumbered (site work was authorized, but not paid) a total of $427.7 million on hazardous waste activities. The three largest states were California with expenditures of $57 million, New Jersey with $48.9 million, and Alaska with $47 million. The states used these funds for nine basic activities: emergency response, removals, site investigation, study and design, remedial actions, operation and maintenance, matching CERCLA funds to pay the state share for NPL sites, grants to cities and local governments, and victim compensation.[5] How funds were distributed among these activities is unknown.

The current balance of state "Superfunds" indicates that states plan to spend substantial money for hazardous waste remediation in the future. By the end of 1991, 49 states and Puerto Rico had established cleanup funds to pay for some or all types of remedial and removal activities. The total of these funds' unobligated balances equalled $586.2 million. In addition, six states have authorized, but not issued, a total of $1.6 billion in bonds.[5] The total of unobligated balances and unissued, authorized bonds equals $2.2 billion.

8.2.5 Remedial Technologies

According to the GAO, both treatment and containment remedies are used to clean up state hazardous waste sites.[6] Thirty states indicated that they have used treatment technologies at least once at hazardous waste sites, and as many as 17 states reported using innovative treatment technologies, including biodegradation (17 states) and soil washing/flushing (9 states). Off-site disposal was used at least once by 35 states, while on-site containment was used by 26 states. To treat ground water, 26 states used pump-and-treat technologies while 24 used alternate water supplies. GAO noted that there was no obvious relationship between states with large cleanup funds and the use of treatment technologies versus containment and disposal. Similarly, no relationship exists between the number of sites needing attention in a state and the use of cleanup technologies versus containment.

8.3 Market for Private Party Sites

In addition to state and federal agency sites, an unknown number of private party sites may require remediation of hazardous chemicals. These sites are located on private property and have not been reported to either federal or state authorities. The owners of these sites may decide to clean up the property without federal or state intervention. Although no data are available on the number of private party sites needing cleanup or on the total cost to remediate these sites, the market for private party remediation is estimated to be quite large. A consulting firm recently estimated that the 1991 market for private party remediation was about $1 billion.[10]

Exhibit 8-5: State Hazardous Waste Funds: 1991 Expenditures/Encumbrances and Balances

States	Expenditures & Encumbrances[a]	Fund Balance[b]	States	Expenditures & Encumbrances[a]	Fund Balance[b]
Alabama	$10,000	$147,000	Montana	$790,000	$11,000,000[e]
Alaska	$47,000,000	$28,700,000	Nebraska	No Fund	—
Arizona	≈$3,500,000	$11,600,000	Nevada	$800,000	$3,000,000
Arkansas	$156,000	$3,246,000	New Hampshire	$2,570,000	$3,400,000
California	$57,000,000	$3,000,000	New Jersey	$48,900,000	$410,100,000[f]
Colorado	$10,000,000	$11,000,000	New Mexico	$215,000	$191,000
Connecticut	$2,350,000	$20,550,000	New York	$20,200,000	$976,500,000[g]
Delaware	≈$200,000	$2,500,000	North Carolina	$165,000	$680,000
Dist. of Columbia	No Fund	—	North Dakota	$0	$59,000
Florida	$8,100,000	$13,667,000	Ohio	$7,700,000	$34,600,000
Georgia	$0	$2,800,000	Oklahoma	$25,000	$60,000
Hawaii	$117,000	$120,000	Oregon	$6,500,000	$3,900,000
Idaho	$8,000	$524,000	Pennsylvania	$38,000,000	$21,800,000
Illinois	$9,600,000	$7,700,000	Puerto Rico	$1,100,000	$2,900,000
Indiana	$1,800,000	$16,600,000	Rhode Island	N/A	$800,000
Iowa	$95,700	$314,000	South Carolina	$3,500,000	$10,000,000
Kansas	N/A	$672,000	South Dakota	$92,000	$976,000
Kentucky	$100,000	≈$5,000,000	Tennessee	$1,800,000	$4,600,000
Louisiana	$1,200,000	$2,200,000	Texas	$41,000,000	$29,800,000
Maine	$11,000,000	$20,700,000	Utah	$335,000	$1,500,000
Maryland	$1,200,000	$8,250,000	Vermont	$4,315,000	$4,100,000
Massachusetts	$18,300,000	$37,000,000[c]	Virginia	$111,000	$73,000
Michigan	$29,900,000	$398,000,000[d]	Washington	$35,600,000	$68,900,000
Minnesota	$7,000,000	$19,100,000	West Virginia	$395,000	$1,220,000
Mississippi	$211,000	$200,000	Wisconsin	$4,000,000	$8,500,000[h]
Missouri	$684,000	$5,300,000	Wyoming	$150,000	$1,000,000
			Total	$427,794,700	$2,218,549,000

Notes:

[a] Includes both expended, obligated, and encumbered funds.

[b] Includes unobligated funds and bonds that have been authorized to be issued. Approximately, $1,614,800,000 in bonds have been authorized by six states.

[c] All $37,000,000 is in authorized bonds.

[d] Includes $387,300,000 in authorized bonds.

[e] Includes $10,000,000 in authorized bonds.

[f] Includes $200,000,000 in authorized bonds.

[g] Includes $973,000,000 in authorized bonds.

[h] Includes $7,500,000 in authorized bonds.

Source: U.S. EPA, Office of Emergency and Remedial Response, *An Analysis of State Superfund Programs: 50 State Study, 1991 Update*, December 1991.

8.4 References

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3. U.S. Environmental Protection Agency, "National Oil and Hazardous Substances Pollution Contingency Plan; Lender Liability Under CERCLA," 57 *Federal Register*, No. 83, p. 18344, April 29, 1992.

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5. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "An Analysis of State Superfund Programs: 50 State Study, 1991 Update," Pub. 9375.6-08B, September 1991.

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8. New Jersey Department of Environmental Protection and Energy, "1992 Site Remediation Program Site Status Report," Fall 1992.

9. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, "Superfund CERCLIS Characterization Project: National Results," EPA/540/8-91/080, November 1991.

10. "Steady Growth in Remediation," *Environmental Business Journal* Vol. 3, March 1992.

APPENDICES

APPENDIX A
SUPPORTING DATA FOR MARKET ANALYSIS

Exhibit A-1: Number of Superfund Source Control RODs Through Fiscal Year 1991

Fiscal Year	Some Treatment	Disposal	Other	Total Source Control RODs
1982	1	3	0	4
1983	0	7	0	7
1984	6	17	0	23
1985	19	37	1	57
1986	27	33	0	60
1987	27	26	0	53
1988	69	28	3	100
1989	77	29	0	106
1990	87	36	2	125
1991	105	34	2	141
Totals	418	250	8	676

Notes:
- RODs denote Records of Decision.
- "Other" includes institutional controls, monitoring, and relocation remedies.

Source: U.S. EPA, Office of Emergency and Remedial Response, 1992.

Exhibit A-2: Representative Hazardous Chemicals by Contaminant Group

The hazardous chemicals listed below are representative of those found at National Priorities List (NPL) sites. The list is developed from site assessment information for NPL sites without Records of Decision (RODs), based on the *Test Methods for Evaluating Solid Waste, Volume 1A: Laboratory Manual, Physical/Chemical Methods*. These chemicals represent many, but not all, of the contaminants found at NPL sites.

Volatile Organic Compounds (VOCs)	
1,1,1-Trichloroethane	Dibromochloromethane
1,1,2,2-Tetrachloroethane	Dibromochloropropane (DBCP)
1,1,2-Trichloroethane	Dibromomethane
1,1-Dichloroethane	Dichlorodifluoromethane
1,1-Dichloroethene	Dichloroethylene
1,1-Dichloropropylene	Dichloromethane
1,2,3-Trichloropropane	Dichlorpropene
1,2-Dichloroethane	Ethyl Ether
1,2-Dichloroethene	Ethyl Methacrylate
1,2-Dichloropropane	Ethylbenzene
1,2-Transdichloroethene	Iodomethane
1,3-Dichloropropane	Isopropanol
1,3-Trichloropropene	M-PSA
1,4-Dichloro-2-butene	M-Xylene
2-Butanone (MEK)	Methane
2-Chloroethyl Vinyl Ether	Methanethiol
2-Chloropropane	Methylene
2-Hexanone	Methylene Chloride
3-Hexanone	O-Xylene
4-Methyl-2-pentanone	P-PSA
Acetone	P-Xylene
Acrolein	Polyvinyl Chloride
Acrylonitrile	Styrene
Benzene	Tetrachloroethene
Bromodichloromethane	Tetrachloroethylene
Bromodichloroethane	Tetrahydrofuran
Bromoform	Toluene
Bromomethane	Total Xylenes
Carbon Disulfide	Trans-1, 2-dichloroethene
Carbon Tetrachloride	Trans-1,3-dichloropropene
Chlorobenzene	Trichloroethene
Chloroethane	Trichlorofluoromethane
Chloroform	Vinyl Acetate
Chloromethane	Vinyl Chloride
Cis-1,2-Dichloroethane	Vinyllidene Chloride
Cis-1,2-Dichloroethylene	Volatile Organics
Cis-1,3-Dichloropropene	

Exhibit A-2: Representative Hazardous Chemicals by Contaminant Group (Continued)

Semi-Volatile Organic Compounds (SVOCs)	
(Lindane) Gamma-BHC	Acenaphthene
1,2,3-Trichlorobenzene	Acenaphthylene
1,2,4,5-Tetrachlorobenzene	Acetophenone
1,2,4-Trichlorobenzene	Aldrin
1,2-Dichlorobenzene	Alpha-BHC
1,2-Diphenylhydrazine	Amiben
1,3-Dichlorobenzene	Aniline
1,4-Dichlorobenzene	Anthracene
1-Chloroaniline	Benzidine
1-Naphthylamine	Benzo(a)anthracene
2,2-Dichlorobenzidine	Benzo(a)pyrene
2,3,4,5-Tetrachlorophenol	Benzo(b)fluorathene
2,4,5-Trichlorophenol	Benzo (ghi)perylene
2,4,6-Trichlorophenol	Benzo(k)flouranthene
2,4-Dichlorophenol	Benzo(j)flourathene
2,4-Dichlorotoluene	Benzo(k)pyrene
2,4-Dimethylphenol	Benzoic Acid
2,4-Dinitrophenol	Benzothiazole
2,4-Dinitrotoluene	Benzyl Alcohol
2,6-Dichlorophenol	Bis(2-chloroethoxy)methane
2,6-Dinitrotoluene	Bis(2-chloroethyl)ether
2-Chloronaphthalene	Bis(ethylhexyl)phthalate
2-Chlorophenol	Bis-2-chloroethoxyphthalate
2-Mercaptan-Benzothiazole	Butyl Benzyl Phthalate
2-Methyl-4,6-Dinitrophenol	Chlordane
2-Methylnaphthalene	Chrysene
2-Methylphenol	Cresote
2-Napthylamine	Delta-BHC
2-Nitroaniline	DHD
2-Nitrophenol	Di-n-octyl Phthalate
2-Picoline	Dibenzo(a,h)anthracene
3-Methylcholanthrene	Dibenzofuran
3-Methylphenol	Dibutyl Phthalate
3-Nitroaniline	Dimethyl Phthalate
4,4-DDD	Dinitrophenol
4,4-DDE	Dinoseb
4,4-DDT	Diphenylamine
4,6-Dinitro-o-cresol	DNB
4-Aminobiphenyl	Endosulfan I
4-Bromophenyl Phenyl Ether	Endosulfan II
4-Chloro-3-methylphenol	Endosulfan Sulfate
4-Chloroaniline	Endrin
4-Chlorophenyl Phenyl Ether	Endrin Aldehyde
4-Methylphenol	EPTC
4-Nitroaniline	Ethyl Methanesulfonate
4-Nitrophenol	Ethylamylketone (EAK)
7,12-Dimethylbenz(a)anthracene	Ethylene Dibromide
A,A-Dimethyl-b-phenylethlamine	Fluoranethene
Acenanthrene	Fluorene

Exhibit A-2: Representative Hazardous Chemicals by Contaminant Group (Continued)

Semi-Volatile Organic Compounds (SVOCs) (Continued)	
Heptachlor	Parathion
Heptachlorepoxide	PCB
Herbicides	Pentachlorobenzene
Hexachlorobenzene	Pentachloronitrobenzene
Hexachlorobutadiene	Pentachlorophenol
Hexachlorocyclohexan	Pesticides
Hexachlorocyclopentadiene	Phenacetin
Hexachloroethane	Phenanthrene
Hexadecanoic Acid	Phenol
Indeno(1,2,3-cd)pyrene	Phenothiazine
Isophorone	Polynuclear Aromatic Hydrocarbons
Kepone	Pronamid
Malathion	Pyrene
Methoxychlor	P-Dimethylaminoazobenzene
Methyl Ethyl Benzene	Resorcinol
Methylmethanesulfonate	Shell Sol 140
N-Methylpyrrolidene	TDX
N-Nitroso-di-n-butylamine	Tertbutylmethylether
N-Nitrosodimethylamine	Tetrahydrofuran
N-Nitrosopiperidine	TNB 1,3,5-Trinitrobenzene
Naphthalene	Toxaphene
Nitrobenzene	Vernolate
Oxazolidone	

Metals	
Aluminum	Molybdenum
Antimony	Nickel
Arsenic	Plutonium
Barium	Potassium
Beryllium	Radium
Boron	Selenium
Cadmium	Silicon
Calcium	Silver
Cesium	Sodium
Chrome	Strontium
Chromite	Technetium
Chromium	Thallium
Cobalt	Thorium
Copper	Tin
Iron	Titanium
Lead	Tritium
Magnesium	Uranium
Manganese	Vanadium
Mercury	Zinc
Metals	Zirconium

Exhibit A-3: Summary of 523 NPL Sites Without RODs

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
ALABAMA			
Olin/McIntosh	93/3	GW, Soil	Metal
Redwing Carriers/Saraland	93/1	Soil	SVOC (PAH, other)
T.H. Agriculture Nutrition	93/3	GW	SVOC (pest)
USA Alabama Army Ammunition	92/4	GW	SVOC (other), Metal
ALASKA			
Alaska Battery Enterprises	93/2	Soil	Metal
Arctic Surplus	95/2	GW, Soil	SVOC (PAH, PCB, pest, other), Metal
Eielson Air Force Base	94/2	GW, Soil	VOC (chlor), Metal
Elmendorf Air Force Base	94/3	GW, Soil	VOC (chlor), Metal
Fort Wainwright	95/4	GW, Soil	SVOC (other), Metal
Standard Steel & Metals Salvage Yard (US DOT)	95/1	GW, Sediment	VOC (chlor), SVOC (PCB), Metal
ARIZONA			
Apache Powder	94/3	GW, Soil	Metal
Hassayampa	92/4	GW, Soil	VOC (chlor)
Luke Air Force Base	94/1	GW, Soil	VOC (BTEX, chlor, nonchlor), SVOC (pest, other)
Williams Air Force Base	94/2	GW, Soil	VOC (BTEX), Metal
Yuma Marine Corps Air Station	96/4	Soil	VOC (chlor, nonchlor)
ARKANSAS			
Frit Industries	NP	NP	NP
Monroe Auto Parts	94/2	GW, Sludge, Soil	VOC (chlor), Metal
CALIFORNIA			
Advanced Micro Devices	91/2	GW, Soil	VOC (chlor)
Aerojet General	94/4	GW, Soil	VOC (chlor)
Barstow Marine Corps Logistics Base	96/1	GW, Soil	VOC (chlor)
Brown & Bryant Arvin Facility	93/4	GW, Soil	VOC (chlor), SVOC (pest)
Camp Pendleton Marine Corps Base	95/1	Soil	VOC (BTEX, chlor, nonchlor), SVOC (pest), Metal
Crazy Horse Sanitary Landfill	95/2	GW, Soil	VOC (BTEX)
Edwards Air Force Base	96/3	GW, Soil	VOC (chlor), SVOC (pest), Metal
El Toro Marine Corps Air Station	96/2	GW, Soil	VOC (chlor), SVOC (PCB)
Fort Ord	94/2	GW, Soil	VOC (chlor)
Fresno Sanitary Landfill	93/3	GW, Soil	VOC (chlor, nonchlor)
George Air Force Base	93/4	GW, Soil	VOC (BTEX, chlor)
Hewlett Packard I Palo Alto	94/2	GW, Soil	VOC (BTEX, chlor)
Industrial Waste Processing	94/1	GW, Soil	VOC (BTEX, chlor, nonchlor)
Jasco Chemical	94/4	GW, Soil	VOC (chlor), Metal
Lawrence Livermore Lab (US DOE)	92/4	GW, Soil	VOC (chlor), SVOC (other)
Lawrence Livermore Nat Lab Site 300	92/4	GW, Soil	VOC (chlor), Metal
Liquid Gold Oil	94/3	GW, Soil	VOC (chlor), Metal
Liquid Gold Oil	93/3	Soil	SVOC (other), Metal
March Air Force Base	94/4	GW, Soil	VOC (BTEX, chlor)
Mather Air Force Base	93/2	GW	VOC (chlor)
McClellan AFB	95/1	GW, Sludge, Soil	VOC (chlor)
Micro Storage/Intel Magnetics	91/4	GW, Soil	VOC (chlor)
Modesto Ground water Contamination	94/2	GW	VOC (chlor)
Moffett Naval Air Station	94/1	GW, Soil	VOC (not specified)
Montrose Chemical	93/4	GW, Soil	SVOC (pest)
Newmark Ground water Contamination	93/3	GW	VOC (chlor)
Norton Air Force Base (Landfill #2)	93/3	GW, Soil	VOC (chlor), SVOC (PCB), Metal
Pacific Coast Pipe Lines	92/2	GW, Soil	VOC (BTEX), SVOC (other), Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
CALIFORNIA (Continued)			
Riverbank Army Ammunition Depot	93/3	GW, Sludge, Soil	VOC (chlor), Metal
San Fernando Valley (Area 2)	93/2	GW	VOC (chlor)
San Fernando Valley (Area 3)	95/1	GW	VOC (chlor)
San Fernando Valley (Area 4)	94/4	GW	VOC (chlor)
San Gabriel Valley (Area 3)	94/2	GW	VOC (chlor)
Sharpe Army Depot	94/3	GW, Sludge, Soil	VOC (chlor)
Southern Cal Edison (Visalia Pole Yard)	93/3	GW, Soil	SVOC (PAH, other)
Sulphur Bank Mercury Mine	94/3	Sediment	Metal
T.H. Agriculture & Nutrition	94/1	GW, Soil	SVOC (pest)
Tracy Defense Depot	93/4	GW, Soil	VOC (chlor)
Travis Air Force Base	94/2	GW, Soil	VOC (BTEX, chlor), SVOC (pest), Metal
Treasure Island Naval Station Annex	94/1	GW, Sed, Soil	VOC (BTEX), SVOC (PCB), Metal
United Heckathorn	94/3	Sediment, Soil	VOC (BTEX), SVOC (pest)
Waste Disposal	93/4	Soil	VOC (BTEX), SVOC (PAH, other)
Western Pacific Railroad Oroville	95/2	GW, Sludge, Soil	VOC (chlor, BTEX), Metal
Westinghouse (Sunnyvale Plant)	92/1	GW, Soil	SVOC (PCB, other)
COLORADO			
Air Force Plants PJKS Property	93/1	GW, Sludge	VOC (chlor), Metal
Lowry	94/1	GW, Soil	VOC (BTEX, chlor)
CONNECTICUT			
Barkhamsted-New Hartford	95/1	GW, Sludge	VOC (BTEX, chlor, nonchlor), Metal
Cheshire Associates Property	97/1	GW, Soil	VOC (BTEX, chlor)
Durham Meadows	96/1	GW, Soil	VOC (chlor)
Gallup's Quarry	95/4	GW, Soil	VOC (BTEX, chlor, nonchlor), Metal
Linemaster Switch	93/3	GW, Sed, Soil	VOC (chlor)
Nutmeg Valley Road	96/1	Soil	VOC (chlor), Metal
Old Southington	93/4	GW, Soil	VOC (chlor)
Precision Plating	96/3	GW	Metal
Revere Textile Prints	92/4	GW, Soil	VOC (BTEX, chlor), Metal
US Naval Submarine Base, New London	94/3	Sediment	SVOC (pest), Metal
DELAWARE			
Chem-Solv	92/2	GW, Soil	VOC (chlor)
Dover Gas Light	93/3	GW, Soil	VOC (BTEX, chlor), Metal
E.I. Du Pont, Newport	93/2	GW, Soil	VOC (chlor), Metal
Kent City	NP	GW, Soil	VOC (nonchlor), SVOC (other), Metal
Koppers Co Facilities	94/4	Sediment, Soil	SVOC (PAH, other)
Standard Chlorine	94/1	GW, Soil	VOC (chlor)
Sussex #5	94/2	GW, Soil	VOC (BTEX, chlor)
Tyler Refrigeration Pit	94/1	GW, Soil	VOC (BTEX, chlor), Metal
FLORIDA			
Agrico Chemical	93/3	GW, Soil	Metal
Airco Plating	93/3	GW, Soil	Metal
Anaconda/Milgo (N. Miami)	96/2	GW, Soil	Metal
Anodyne	93/2	GW, Soil	SVOC (PCB), Metal
B&B Chemical Company	94/2	GW, Soil	VOC (chlor), SVOC (other), Metal
Beulah	93/3	GW, Soil	SVOC (PAH, PCB, pest, other), Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
FLORIDA (Continued)			
BMI Textron	95/1	GW, Soil	Metal
Cecil Field Naval Air Station	93/4	GW, Soil	Metal
Chem-Form	94/2	GW, Soil	Metal
Florida Steel	93/4	NP	Metal
Homestead Air Force Base	92/3	GW, Soil	VOC (nonchlor), Metal
Jacksonville Naval Air Station	95/4	GW, Soil	VOC (chlor), SVOC (PCB), Metal
Madison County Sanitary	92/4	GW, Soil	VOC (chlor)
Peak Oil	93/2	GW, Sed, Sludge, Soil	SVOC (PCB, pest, other), Metal
Pensacola Naval Air Station	94/1	GW, Soil	VOC (BTEX), SVOC (PCB, pest)
Piper Aircraft Vero Beach Division	95/2	GW, Soil	VOC (chlor)
Reeves Southeastern Galvanizing	93/2	GW, Soil	Metal
Standard Auto Bumper	93/4	GW, Sludge, Soil	Metal
Taylor Rd	95/4	GW	VOC (not specified)
Wilson Concepts of Florida	92/4	GW, Soil	VOC (chlor)
Wingate Rd. Municipal Incinerator Dump	94/2	Sediment, Soil	SVOC (pest)
Woodbury Chemical	92/3	Soil	SVOC (pest)
GEORGIA			
Cedartown Industries	93/2	Sludge, Soil	Metal
Cedartown Municipal	93/2	GW, Soil	VOC (BTEX, chlor), SVOC (PAH, other), Metal
Diamond Shamrock	94/2	NP	SVOC (pest), Metal
Firestone Tire & Rubber	93/2	GW, Soil	VOC (BTEX, chlor), Metal
Marine Corps Logistics Base	94/2	GW, Sed, Sludge, Soil	VOC (chlor), SVOC (PCB, pest)
Marzone/Chevron Chemical	93/3	GW, Soil	SVOC (pest)
Mathis Bros (S. Marble Top Rd)	93/2	Soil	SVOC (pest, other), Metal
T.H. Agriculture & Nutrition	93/2	GW, Soil	SVOC (pest)
Woolfolk Chemical Works	93/3	GW, Soil	SVOC (pest), Metal
HAWAII			
Schofield Barracks	95/2	GW, Soil	VOC (chlor)
IDAHO			
Arrcom (Drexler Enterprise)	92/3	Soil	VOC (chlor)
Eastern Michaud Flats Contamination	94/3	GW, Sediment, Soil	Metal
Idaho National Engineering Lab (US DOE)	93/3	GW, Soil	VOC (chlor), Metal
Kerr-McGee	94/4	GW, Soil	Metal
Monsanto - Soda Springs	94/4	GW, Sediment, Soil	Metal
Mountain Home Air Force Base	93/3	GW, Sediment, Soil	VOC (BTEX, nonchlor), Metal
ILLINOIS			
Adams County Quincy #2 & #3	93/2	GW, Soil	VOC (BTEX, chlor), Metal
Amoco	94/2	GW, Soil	VOC (BTEX), SVOC (other), Metal
Beloit	94/2	GW, Sediment, Soil	VOC (BTEX, chlor)
Central Illinois Public Service	92/4	GW, Sediment, Soil	VOC (BTEX), SVOC (PAH, other)
Dupage County Blackwell Forest	93/4	GW, Soil	VOC (chlor)
HOD	95/1	GW, Soil	SVOC (PCB), Metal
Ilada Energy	93/1	GW, Soil	SVOC (PCB), Metal
Interstate Pollution Control	95/3	GW, Soil	VOC (chlor)
Joliet Army Ammo Plant Lap Area	94/1	GW, Soil	Metal
Joliet my Ammo Plant Mfg.	94/1	GW, Soil	Others
Kerr-McGee Kress Creek & West Branch	95/3	NP	Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
ILLINOIS (Continued)			
Kerr-McGee Reed Keppler Park	95/3	Soil	Metal
Kerr-McGee Residential Areas	NP	Soil	Others
Kerr-McGee Sewage Treatment	95/3	Soil	Others
Lenz Oil	94/2	GW, Soil	VOC (chlor, nonchlor)
Mig/Dewane	94/2	GW, Soil	VOC (chlor), Metal
Parson's Casket Hardware	93/4	GW, Soil	Metal
Savanna Army Depot	94/3	GW, Soil	VOC (nonchlor), others
Tri County Landfill Waste Mgmt of IL	92/4	GW, Soil	VOC (BTEX, chlor), Metal
Woodstock Municipal	93/3	Soil	Metal
Yeoman Creek	94/4	Sediment	SVOC (PCB)
INDIANA			
American Chemical	92/4	GW, Soil	VOC (BTEX, chlor), SVOC (other)
Bennett Stone Quarry	NP	Sediment	SVOC (PCB)
Carter Lee Lumber	95/2	GW, Soil	SVOC (PAH, other), Metal
Columbus Old Municipal	92/2	GW, Soil	SVOC (PCB), Metal
Continental Steel Corp.	94/2	GW, Soil	Metal
Douglas Road Uniroyal	95/1	NP	VOC (BTEX, chlor, nonchlor), SVOC (other)
Galen Meyer's Dump/Drum Salvage	95/3	GW, Soil	VOC (chlor)
Himco Dump	93/1	GW, Soil	Metal
Lakeland Disposal	93/4	GW, Soil	Metal
Lemon Lane	NP	Soil	SVOC (PCB)
Neals Dump	NP	NP	SVOC (PCB)
Neals Landfill Bloomington	NP	Sediment, Soil	SVOC (PCB)
Prestolite Battery Division	93/2	Soil	SVOC (PCB), Metal
Reilly Tar & Chemical Indiana	93/2	GW, Soil	SVOC (PAH, other)
Southside Sanitary	94/1	GW, Soil	Metal
Tippecanoe Sanitary Landfill	95/1	GW, Sludge, Soil	VOC (nonchlor), SVOC (PCB), Metal
Waste Inc.	93/4	GW, Soil	SVOC (PCB, pest), Metal
Whiteford Sales & Service National Lease	94/1	Soil	VOC (BTEX), Metal
IOWA			
E.I. Du Pont De Nemours & Co. (CO RDx23)	91/3	GW	Metal
Electro-Coatings	93/3	GW	Metal
Farmers Mutual Cooperative	92/4	GW, Soil	VOC (chlor)
Iowa Army Ammunition Plant	95/2	GW, Sediment	SVOC (other), Metal
Labounty Dump	NP	GW, Sludge	Metal
Red Oak City	93/1	GW, Sediment	VOC (BTEX, chlor), Metal
Sheller-Globe Disposal	93/3	GW, Sludge, Soil	VOC (BTEX, chlor), Metal
KANSAS			
29th & Mead Ground Water Contamination	93/4	GW, Soil	VOC (BTEX, chlor), Metal
Ft. Riley	95/1	GW	VOC (chlor), SVOC (pest), Metal
Hydro-Flex	92/2	GW, Soil	Metal
Obee Road	94/2	GW, Soil	VOC (BTEX, chlor)
Pester Refinery	92/4	GW, Sediment, Sludge, Soil	VOC (BTEX, chlor), Metal
Strother Field	93/3	GW, Soil	VOC (chlor), Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
KENTUCKY			
Brantley	94/1	NP	Metal
Caldwell Lace Leather	93/4	GW, Sludge, Soil	Metal
Fort Hartford Coal Stone Quarry	94/2	NP	Metal
General Tire & Rubber	93/2	NP	VOC (BTEX, chlor), Metal
Green River Disposal	93/3	GW, Soil	SVOC (PCB, other), Metal
Red-Penn Sanitation	93/4	Soil	VOC (BTEX, chlor), SVOC (PAH, PCB, other), Metal
LOUISIANA			
Combustion	94/2	GW, Soil	Metal
D.L. Mud	93/2	GW, Soil	Metal
Dutchtown Treatment	93/4	GW, Sludge, Soil	VOC (BTEX, chlor)
Gulf Coast Vacuum	92/4	Sludge, Soil	VOC (BTEX), Metal
Pab Oil & Chemical Services	93/4	Sludge, Soil	VOC (BTEX, nonchlor) Metal
Petro-Processors of Louisiana	NP	GW	Others
MAINE			
Brunswick Naval Air Station	93/4	NP	SVOC (pest)
Loring Air Force Base	93/4	GW, Soil	VOC (chlor), Metal
Saco Municipal	97/4	GW, Sediment, Soil	Metal
MARYLAND			
Anne Arundel	94/1	GW, Soil	VOC (chlor), Metal
Bush Valley	94/1	GW, Soil	VOC (chlor)
Woodlawn	93/4	GW, Sediment, Soil	VOC (BTEX, chlor, nonchlor), Metal
MASSACHUSETTS			
Atlas Tack	94/2	GW, Sediment, Soil	VOC (BTEX), Metal
Fort Devens - Sudbury Training Annex	95/1	GW, Soil	VOC (BTEX, chlor), SVOC (other)
Ft. Devens	94/3	GW	Metal
Haverhill Municipal	96/2	GW, Soil	VOC (BTEX)
Otis Air National Guard/Camp Edwards	93/2	GW, Soil	VOC (chlor)
PSC Resources	92/4	Soil	VOC (chlor), SVOC (PCB)
Salem Acres	92/2	Soil	VOC (chlor), SVOC (PCB), Metal
Shpack	95/2	GW, Soil	VOC (chlor), Metal
MICHIGAN			
Adams Plating	94/2	Soil	VOC (chlor), Metal
Albion Sheridan Twp.	94/2	Sludge	Metal
Allied Corp. Kalamazoo Plant	95/1	GW, Sediment	SVOC (PCB)
American Anodco	93/3	NP	Metal
Avenue "E" Ground Water Contamination	NP	GW	VOC (BTEX, nonchlor)
Barrels	NP	GW	Metal
Bendix Corp/Allied Automotive	94/1	GW, Soil	VOC (chlor)
Butterworth #2	92/4	NP	Metal
Cannelton Industries	92/4	GW, Sediment, Soil	Metal
Duell & Gardner	93/4	Soil	SVOC (PCB)
Electrovoice	93/4	GW, Soil	VOC (BTEX, chlor)
Grand Traverse Overall Supply	92/2	GW, Soil	VOC (chlor)
Gratiot County	NP	GW	Metal
H. Brown	92/4	Soil	Metal
J&L	93/2	Soil	Metal
Kaydon	NP	GW, Sludge, Soil	VOC (chlor), Metal
Kent City Mobile Home Park	NP	GW	VOC (BTEX, chlor)
McGraw-Edison	NP	GW	VOC (chlor)

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
MICHIGAN (Continued)			
Metal Working Shop	92/3	Soil	Metal
Muskegon Chemical	94/1	GW, Soil	VOC (chlor), SVOC (other)
North Bronson Industrial Area	94/2	GW, Soil	VOC (chlor), Metal
Packaging Chemical Works	93/4	GW, Soil	Metal
Parsons Chemical Works	94/4	GW, Sediment, Soil	SVOC (pest)
Peerless Plating	92/4	GW, Soil	VOC (chlor), Metal
Petoskey Municipal Well Field	95/1	GW	VOC (chlor)
Rockwell Intl. Allegan Plant	95/1	GW, Sediment, Soil	VOC (nonchlor), Metal
Roto-Finish	94/1	GW, Soil	Metal
SCA Independent	96/4	GW	VOC (BTEX, chlor, nonchlor), SVOC (other)
Shiawessee River	93/4	GW, Sediment, Soil	SVOC (PCB)
Southwest Ottawa County	NP	GW	Metal
Sparta	94/4	GW	VOC (BTEX)
Spartan Chemical	95/3	GW	VOC (chlor)
State Disposal	94/2	GW	VOC (BTEX, chlor), Metal
Tar Lake	92/4	GW, Sludge, Soil	Metal
Torch Lake	92/4	Sediment	Metal
Velsicol Chemical Mich.	NP	Soil	SVOC (not specified)
Wash King Laundry	93/2	GW	VOC (chlor)
Waste Mgmt of Michigan Holland	93/4	GW	VOC (chlor)
MINNESOTA			
Agate Lake Scrap Yard	93/2	Soil	VOC (chlor), SVOC (PCB)
Boise Cascade/Onan/Medtronics	NP	GW, Sludge, Soil	SVOC (PAH, other)
East Bethel Demolition Landfill	93/1	GW	VOC (chlor), Metal
Freeway Sanitary	93/3	GW, Soil	Metal
General Mills/Henkel	NP	GW, Soil	VOC (not specified)
Joslyn Mfg. and Supply	NP	GW, Sludge, Soil	SVOC (PAH, other), Metal
Koch Ref. Co/N-Ren	91/4	GW, Soil	SVOC (chlor)
Koppers Coke	93/3	GW, Soil	Metal
Kurt Mfg.	NP	GW, Soil	VOC (chlor)
Lagrand Sanitary Landfill	92/4	GW, Soil	VOC (chlor), SVOC (other)
Nutting Truck and Caster	NP	GW, Soil	VOC (chlor)
Olmsted County Sanitary Landfill	93/4	GW, Soil	VOC (chlor, nonchlor), Metal
Perham Arsenic	94/2	GW, Soil	Metal
Ritari Post & Pole	93/3	GW, Sludge, Soil	SVOC (other)
St. Augusta Landfill/Engen Dump	93/3	GW, Soil	VOC (BTEX, chlor), SVOC (other), Metal
Twin Cities AFB (Small Arms Range Landfill)	92/2	GW, Sludge, Soil	VOC (chlor), Metal
MISSOURI			
Bee Cee Manufacturing	93/3	Soil	Metal
Lake City Army Ammunition	94/1	GW	Metal
North U Drive Well Contamination	93/2	GW	VOC (not specified)
Oronogo Duenwig Mining Belt	94/2	GW, Soil	Metal
Quality Plating	93/3	GW, Soil	Metal
St. Louis Airport/His/Futura Coating	95/2	GW, Soil	Metal
Valley Park TCE	94/1	GW	VOC (chlor)
Weldon Springs Ordnance Works (Former)	95/2	GW, Soil	SVOC (other)
Westlake	95/2	NP	Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
MONTANA			
Idaho Pole	92/4	Soil	SVOC (other)
Montana Pole and Treating	93/3	GW, Soil	SVOC (other)
Mouat Industries	95/4	GW, Soil	Metal
NEBRASKA			
10th Street Site	93/2	GW, Soil	VOC (chlor)
Cornhusker Army Ammunition	95/1	GW, Soil	Others
Nebraska Army Ordnance	93/4	GW, Soil	VOC (chlor), SVOC (PCB)
NEVADA			
Carson River Mercury	94/4	Sediment	Metal
NEW HAMPSHIRE			
Fletcher's Paint Works	94/3	Sediment, Soil	VOC (BTEX, chlor), SVOC (PCB), Metal
Holton Circle	92/4	GW, Soil	VOC (chlor)
Pease Air Force Base	93/2	GW, Sediment, Soil	VOC (chlor), SVOC (pest), Metal
Tibbetts Road	92/4	GW, Soil	VOC (BTEX, chlor, nonchlor)
NEW JERSEY			
American Cyanamid	93/3	GW, Sediment, Soil	SVOC (other)
Brick Twp. Landfill	94/1	GW, Soil	VOC (not specified)
Brook Industrial Park	93/3	GW, Soil	SVOC (pest), Metal
Cosden Chemical Coatings	92/4	GW, Soil	VOC (BTEX), SVOC (PCB)
CPS/Madison Industries	95/3	GW, Soil	VOC (BTEX, chlor, nonchlor), Metal
Dayco Corp/L.E. Carpenter	93/2	GW, Sludge, Soil	VOC (nonchlor)
Delilah Road	NP	GW, Sludge, Soil	VOC (chlor), Metal
Denzer & Schafer X-Ray	94/1	GW, Soil	VOC (not specified)
Dover Municipal Well 4	95/3	GW	VOC (not specified)
Ellis Property	92/4	GW	Others
Evor Phillips Leasing	95/2	NP	Others
Fair Lawn Fields	95/4	GW	VOC (chlor)
Fried Industries	93/4	Soil	VOC (chlor), Metal
Hercules	93/3	GW, Soil	VOC (BTEX)
Higgins Disposal Service	95/2	Soil	VOC (chlor), SVOC
Hopkins Farm	94/2	GW, Soil	Metal
Industrial Latex	95/4	Soil	VOC (BTEX)
Jackson Twp. Landfill	94/1	GW	SVOC (other)
JIS Landfill	94/1	GW	VOC (not specified)
Kauffman & Minteer	93/3	Soil	VOC (BTEX, chlor, nonchlor), SVOC (PAH, pest, other)
Landfill & Development	94/3	GW	VOC (not specified)
Lodi Municipal Wells	93/3	GW, Soil	Metal
Maywood Chemical	95/1	Soil	Others
Monitor Devices/Intercircuits	95/2	GW, Soil	Metal
Monroe Township Landfill	94/1	NP	Others
Naval Weapons Station Earle - Site A	94/2	Sediment	Others
PJP Landfill	93/4	GW	VOC (not specified)
Pohatcong Valley Ground Water Contamination	95/2	GW	VOC (chlor)
Radiation Technology	94/1	GW, Soil	VOC (not specified)
Rockaway Twp. Wells	93/3	GW, Soil	VOC (not specified)
Shield Alloy	93/4	GW	Metal
Universal Oil Prod	94/1	GW, Soil	VOC (not specified)

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
NEW JERSEY (Continued)			
U.S. Radium	93/3	NP	Others
Ventron/Velsicol	95/2	GW	Metal
W. R. Grace/Wayne Interim Storage Site (US DOE)	94/4	Soil	Others
Wilson Farm	93/3	NP	VOC (not specified)
Witco Chemical	92/4	Soil	VOC (not specified)
NEW MEXICO			
Cal West Metals (SBA)	92/4	GW, Soil	Metal
Cleveland Mill	93/3	GW, Soil	Metal
Lee Acres Landfill (US DOI)	94/2	GW, Soil	VOC (BTEX, chlor)
Prewitt Abandoned Refinery	92/4	GW, Soil	VOC (BTEX)
NEW YORK			
Action Anodizing & Plating	92/3	Soil	Metal
Anchor Chemicals	94/1	GW	VOC (not specified)
Batavia	93/2	Sludge	Metal
Bioclinical Laboratories	92/4	GW, Soil	VOC (chlor), Metal
Brookhaven National Laboratory	96/1	GW, Soil	VOC (chlor)
Carrol & Dubies	93/4	GW, Soil	VOC (chlor, BTEX), SVOC (other), Metal
Cortese	94/4	GW, Soil	Metal
Facet Enterprises	92/4	GW, Sludge, Soil	VOC (chlor), SVOC (PCB), Metal
FMC - Dublin Rd.	93/2	GW, Soil	SVOC (pest), Metal
Goldisc Recordings	95/1	Sludge	Metal
Griffiss Air Force Base	94/2	GW	VOC (BTEX)
Islip SLF	92/4	GW, Soil	VOC (chlor)
Johnstown City	93/2	GW, Sludge, Soil	Metal
Jones Chemical	95/1	GW, Soil	VOC (chlor)
Jones Sanitation	94/4	GW	VOC (chlor, nonchlor), SVOC (PAH, other), Metal
Kenmark Textile	94/4	GW, Soil	Metal
Liberty Ind. Finishing	93/4	Sludge, Soil	Metal
Mercury Refining	NP	Sediment	SVOC (PCB), Metal
Nepera Chemical	94/2	GW, Sludge, Soil	VOC (chlor), SVOC (other, PCB), Metal
Niagara City Refuse	93/4	Sediment, Soil	NP
Niagara Mohawk/Operations HQ	94/1	NP	SVOC (other)
Pasley Solvents & Chemicals	92/3	GW, Soil	VOC (BTEX, chlor, nonchlor)
Plattsburgh Air Force Base	92/4	GW, Soil	SVOC (PCB, other)
Ramapo	92/2	GW, Soil	VOC (BTEX, chlor)
Richardson Hill Site	94/1	GW, Soil	VOC (BTEX, chlor), SVOC (PCB)
Robintech/National Pipe	93/2	Soil	VOC (BTEX), Metal
Rocket Fuel	94/3	GW	VOC (chlor)
Rosen	94/3	GW	VOC (chlor), SVOC (PAH, other), Metal
Rowe Industries Ground Water Contamination	92/4	GW	SVOC (other)
Seneca Army Depot	94/4	GW, Soil	VOC (chlor)
Sidney	94/3	GW, Sediment, Soil	VOC (BTEX, chlor, nonchlor), SVOC (PCB, other), Metal
Tri-City Barrel	95/1	GW, Soil	VOC (BTEX, nonchlor), SVOC (PCB, pest)

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
NEW YORK (Continued)			
Tronic Plating Company	93/2	Soil	Metal
Vestal Water Supply 4-2	NP	GW	VOC (chlor)
NORTH CAROLINA			
ABC One Hour Cleaning	94/1	GW, Soil	VOC (BTEX, chlor)
Benfield Industries	92/4	Soil	VOC (chlor), SVOC (other)
FCX, Inc. (Washington Plant)	93/3	Soil	VOC (nonchlor), SVOC (PAH, pest, other), Metal
FCX, Inc. (Statesville Plant)	93/4	GW, Soil	SVOC (pest)
Geigy Chemical	92/4	GW, Soil	VOC (BTEX), SVOC (pest), Metal
Hevi Duty Electric/General Signal	95/1	GW	SVOC (PCB)
JFD Electronics/Channel Master	92/4	GW, Sludge, Soil	VOC (chlor), Metal
Koppers Co., Inc. (Morrisville Plant)	93/1	GW, Sediment, Soil	SVOC (other)
NC State U (Lot 86 Farm Unit #1)	94/4	GW, Soil	VOC (chlor, nonchlor), SVOC (pest), Metal
New Hanover County Airport Burn Pit	92/4	Sludge, Soil	VOC (BTEX, chlor, nonchlor), SVOC (PAH, other), Metal
Potter's Septic Tank Svs. Pits	92/4	GW, Soil	VOC (BTEX, nonchlor), Metal
USMC Camp Lejeune Military Reservation	93/4	Soil	SVOC (pest)
NORTH DAKOTA			
Minot	93/3	GW, Soil	VOC (BTEX, chlor, nonchlor), SVOC (other), Metal
OHIO			
Feed Materials Production Ctr.	94/1	GW, Soil	VOC (chlor), SVOC (PCB, other), Metal
Mound Plant (US DOE)	95/1	GW, Soil	Metal
Nease Chemical	94/2	GW	SVOC (pest, other)
Ormet	93/3	GW, Sludge, Soil	Metal
Powell Road	93/2	Sludge, Soil	SVOC (other), Metal
Reilly Tar & Chemical	94/1	GW, Soil	SVOC (PAH, other)
Sanitary Landfill Co. Ind. Waste	93/1	NP	SVOC (other)
Skinner	93/2	NP	SVOC (other), Metal
South Point	93/3	GW, Soil	Others
TRW Inc. Minerva	NP	GW, Sediment, Soil	VOC (chlor), SVOC (PCB)
Van Dale Junkyard	93/2	Sediment	SVOC (other), Metal
Wright Patterson Air Force Base	93/2	GW, Soil	VOC (chlor), Metal
OKLAHOMA			
Double Eagle	93/4	Soil	Metal
Fourth Street Abandoned	93/4	Soil	SVOC (pest), Metal
Mosely Road	92/3	Sludge, Soil	SVOC (pest, other)
Oklahoma	92/3	GW, Soil	VOC (BTEX), Metal
OREGON			
Allied Plating	93/3	GW, Soil	Metal
Joseph Forest Products	92/4	Soil	Metal
Umatilla Army Depot (Lagoons)	93/2	GW, Soil	VOC (chlor), SVOC (pest)
Union Pacific RR/Kerr McGee Tie Point	93/3	GW, Soil	SVOC (PAH, other), Metal
PENNSYLVANIA			
AIW Frank	94/1	GW, Soil	VOC (chlor)
AMP - Glen Rock	94/4	GW, Soil	VOC (chlor)
Bell	93/4	GW	VOC (chlor), Metal
Berkely Prod. Co. Dump	93/4	GW, Soil	VOC (BTEX), SVOC (other), Metal
Berks	94/2	GW, Soil	VOC (BTEX, chlor), Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
PENNSYLVANIA (Continued)			
Boarhead Farms	94/1	GW, Soil	VOC (chlor), Metal
Butler Mine Tunnel	93/2	Soil	SVOC (other)
C&D Recycling	92/4	GW, Soil	Metal
Centre County Kepone	94/1	GW	SVOC (pest)
Commodore Semiconductor Group	92/4	GW, Soil	VOC (chlor)
Dublin Water Supply	94/2	GW	VOC (chlor)
Elizabethtown	94/4	GW, Soil	VOC (BTEX, chlor), Metal
Hunterstown Road	93/3	GW, Soil	VOC (chlor)
Jack's Creek/Sitkin Smelting	93/4	GW, Soil	SVOC (PCB), Metal
Lindane Dump	92/2	Soil	SVOC (pest)
Malvern Ice	94/1	GW, Soil	VOC (chlor), SVOC (PCB)
Metal Banks	94/1	GW	SVOC (PCB)
North Penn-Area 1	93/4	GW	VOC (chlor)
North Penn-Area 2	94/2	GW	VOC (chlor)
North Penn-Area 5	95/1	GW, Soil	VOC (chlor)
North Penn-Area 6	95/1	GW, Soil	VOC (chlor)
North Penn-Area 7	95/3	GW, Soil	VOC (chlor)
Novak Sanitary	93/2	GW, Soil	VOC (chlor)
Occidental Chem/Firestone	93/3	NP	VOC (BTEX, chlor), Metal
Ohio River Park Nevell Island	93/2	GW, Soil	VOC (BTEX, chlor), Metal
Old City of York	91/4	GW, Soil	NP
Paoli Rail Yard	92/4	Soil	VOC (BTEX), SVOC (pest, other)
Recticon/Allied Steel	NP	GW, Soil	VOC (chlor)
Revere Chemical	93/3	Sludge	Metal
River Road Landfill-Waste Mgmt	94/2	GW, Sed, Sludge, Soil	VOC (chlor), SVOC (PCB)
Route 940 Drum Dump	92/4	GW, Soil	VOC (BTEX, chlor)
Saegertown Industrial Area	93/1	GW, Sed, Sludge, Soil	VOC (BTEX, chlor), SVOC (other), Metal
Salford Quarry	94/4	GW	Metal
Shriver's Corner	93/3	GW, Soil	VOC (BTEX, chlor)
Stanley Kessler	93/4	GW, Soil	VOC (chlor)
Tonolli .	92/4	GW, Soil	Metal
Tranisicoil	94/2	GW, Soil	VOC (chlor)
USA Tobyhanna Army Depot	93/2	GW, Sludge, Soil	VOC (chlor), Metal
USA Naval Air Dev. Center	93/3	GW	VOC (chlor), Metal
Westinghouse Elevator Co. Plant	94/1	GW	VOC (chlor)
Westinghouse, Sharon	93/1	GW, Sediment, Soil	SVOC (PCB, other)
York County Solid Waste	93/3	GW, Soil	VOC (chlor, nonchlor)
PUERTO RICO			
Barceloneta	94/3	NP	NP
Naval Security Group Activity	95/4	Soil	SVOC (pest), Metal
RCA Del Caribe	94/1	GW, Sediment	Metal
RHODE ISLAND			
Central	94/1	GW, Soil	NP
Davis (GSR)	94/2	GW, Soil	VOC (BTEX, chlor)
Davisville Naval Construct, Battalion Center	93/4	Sediment, Soil	Metal
Newport Naval Education/Training Center	93/4	GW, Sediment, Soil	Metal
Peterson/Puritan	93/4	GW	SVOC (other)
Rose Hill Regional	94/3	GW, Soil	VOC (BTEX, chlor)

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
SOUTH CAROLINA			
Beaunit Corp/Circular Knit & Dyeing	94/2	GW, Sediment, Sludge, Soil	VOC (chlor), SVOC (PCB, other), Metal
Elmore Waste Disposal	93/2	GW, Sediment, Soil	VOC (BTEX, chlor), Metal
Helena Chemical	93/2	GW, Soil	SVOC (pest)
Kalama Specialty Chemicals	93/3	GW, Soil	VOC (BTEX), Metal
Koppers	94/2	GW, Soil	SVOC (PAH, other)
Leonard Chemical	93/3	GW	SVOC (other)
Lexington County	94/3	GW, Soil	SVOC (pest), Metal
Para Chem Southern	93/4	GW, Sediment, Soil	VOC (chlor, nonchlor), Metal
Rochester Property	94/2	Soil	VOC (chlor), Metal
Rock Hill Chemical Company/Rutledge Prop.	95/1	GW, Sludge, Soil	VOC (chlor), SVOC (PCB), Metal
Savannah River Site (US DOE)	92/4	GW, Soil	VOC (chlor), Metal
Townsend Saw Chain	94/1	GW, Soil	VOC (chlor), Metal
SOUTH DAKOTA			
Ellsworth Air Force Base	96/2	GW, Soil	VOC (chlor), Metal
Williams Pipe Line Co. Disposal Pit	94/3	GW, Sediment, Soil	VOC (BTEX), SVOC (pest), Metal
TENNESSEE			
Carrier Air Conditioning	92/4	GW, Soil	VOC (chlor)
Murray Ohio Mfg. (Horseshoe Bend)	94/1	Soil	Metal
Murray-Ohio Dump	94/1	GW, Sludge, Soil	Metal
USA Milan Army Ammo Pit	93/3	GW	Metal
TEXAS			
Air Force Plant #4 (General Dynamics)	95/1	GW, Soil	VOC (chlor), Metal
Lone Star Army Ammunition Plant	94/3	GW, Soil	Metal
Longhorn Ammunition Plant	95/2	GW, Sediment, Sludge, Soil	Metal
Tex-Tin	94/1	GW, Sludge, Soil	SVOC (pest), Metal
UTAH			
Midvale Slag	93/4	NP	Metal
Rose Park Sludge Pit	NP	Sludge	Others
Tooele Army Depot (North Area)	94/3	GW, Soil	VOC (chlor)
Utah Power & Light/American Barrel	93/4	GW, Soil	VOC (nonchlor)
VERMONT			
Bennington Municipal	94/3	GW, Sediment, Sludge, Soil	VOC (BTEX), SVOC (PCB, other), Metal
BFI/Rockingham	94/1	GW, Soil	VOC (chlor, nonchlor), Metal
Burgess Brothers	95/1	GW, Sludge, Soil	VOC (chlor), Metal
Darling Hill Dump	92/4	GW, Soil	VOC (BTEX, chlor)
Parker	94/2	GW, Soil	VOC (chlor)
Pine Street Canal	93/4	NP	SVOC (other)
Tanistor Electronics	94/1	GW, Soil	VOC (chlor, nonchlor), Metal
VIRGINIA			
Abex	92/4	Soil	Metal
Atlantic Wood Industries	93/3	GW, Sediment, Soil	SVOC (PAH, other)
Buckingham County	93/3	GW, Soil	Metal
Culpeper Wood Preservers	95/1	GW, Soil	Metal
H&H Inc. - Burn Pit	93/3	GW, Soil	VOC (BTEX), SVOC (PCB)
Rentokil Inc. VA Wood Preserving	93/2	GW, Soil	Metal
Suffolk City Landfill	92/4	GW, Soil	SVOC (pest), Metal
U.S. Defense General Supply Center	93/3	GW, Soil	VOC (chlor), SVOC (other), Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
WASHINGTON			
Aluminum Co. of America (Vancouver Smelter)	92/2	GW, Soil	Metal
American Crossarm & Conduct	93/2	GW	SVOC (PAH, other)
Bangor Ordinance Disposal (USN Sub Base)	92/2	GW, Soil	Metal
Bonneville Power Admin. Ross Complex (US DOE)	93/2	GW, Soil	VOC (chlor), SVOC (PCB)
Centralia Municipal	95/1	NP	Metal
Fairchild Air Force Base (4 Areas)	93/2	NP	VOC (chlor), Metal
Fort Lewis (Landfill No. 5)	92/4	GW, Soil	VOC (chlor), SVOC (PCB, pest), Metal
General Electric (Spokane Apparatus)	93/1	GW, Soil	VOC (chlor), SVOC (PCB)
Greenacres	93/1	GW	VOC (not specified)
Hanford 100-Area	95/3	GW, Soil	Metal
Hanford 1100-Area (US DOE)	93/4	NP	Others
Hanford 200-Area (US DOE)	94/1	GW, Soil	VOC (chlor), Metal
Hanford 300-Area (US DOE)	95/2	GW	Metal
Harbor Island - Lead	93/4	GW, Soil	Metal
Hidden Valley San. LF/Thun Field	93/1	GW, Soil	VOC (chlor), SVOC (other), Metal
Kaiser Aluminum Mead Works	93/3	GW	Metal
McChord AFB (Wash Rack/Treatment)	92/4	GW, Soil	VOC (BTEX, chlor), Metal
Mica	94/4	GW, Soil	VOC (chlor, nonchlor)
Midway	93/2	GW, Soil	VOC (BTEX), Metal
N.A.S. Whidbey Island (Ault Field)	93/4	NP	VOC (BTEX, chlor, nonchlor), SVOC (other), Metal
N.A.S. Whidbey Island (Seaplane BS)	93/3	NP	Metal
Naval Undersea Warfare Engineer Station 4 Areas	94/2	Sediment	VOC (chlor, nonchlor) Metal
Northwest Transformer (S. Harkness St.)	94/1	GW, Soil	SVOC (PCB)
Old Inland Pit	NP	NP	VOC (BTEX, chlor, nonchlor), Metal
Pacific Ca. & Foundry	91/4	GW, Soil	Metal
Pasco Sanitary	NP	GW	VOC (chlor), SVOC (pest), Metal
Pesticide Lab - Yakima	92/4	Soil	SVOC (pest)
Seattle Municipal Landfill (Kent Highlan)	92/2	GW, Soil	VOC (chlor), Metal
Tosco (Spokane Terminal)	93/4	Soil	Metal
Wyckoff Co/Eagle Harbor	93/2	Sed, Sludge, Soil	SVOC (PAH, other)
WEST VIRGINIA			
Follansbee	97/1	GW	SVOC (other)
WISCONSIN			
City Disposal Sanitary Landfill	92/4	GW, Soil	Others
Delevan Municipal Well #4	94/1	GW, Soil	VOC (chlor)
Hechimovich	94/1	GW, Soil	VOC (BTEX, chlor), Metal
Kohler	94/3	GW, Soil	Metal
Lauer I Sanitary Landfill	94/2	NP	NP
Madison Metro Sewage Sludge Lagoon	94/3	GW, Sludge	SVOC (PCB)
Mauthe NW	93/4	GW, Soil	Metal
Muskego Sanitary Landfill	93/2	GW, Soil	Metal
Omega Hills North	NP	NP	NP
Sauk County	94/3	GW, Soil	VOC (BTEX, chlor, nonchlor), Metal
Scrap Processing	94/1	GW, Soil	Metal

Exhibit A-3: Summary of 523 NPL Sites Without RODs (Continued)

NPL Sites Without RODs[a] (By State)	Planned[b] ROD Date	Matrices[c]	Contaminant Groups[c]
WISCONSIN (Continued)			
Sheboygan Harbor & River	94/2	Sediment	SVOC (PCB)
Spickler	99/1	GW, Sludge	VOC (BTEX), Metal
Tomah Armory	NP	NP	VOC (chlor), Metal
Tomah Fairground Area	NP	NP	Metal
Tomah Municipal Sanitary Landfill	NP	GW, Sediment	VOC (BTEX, chlor, nonchlor), Metal
Waste Management of Wisconsin-Brookfield	95/1	GW	Metal
Waste Research & Reclamation	NP	GW	Others
WYOMING			
F.E. Warren Air Force Base	94/3	GW, Soil	VOC (chlor), Metal

Notes:

[a] The list reflects the 523 sites without Records of Decision (RODs) as of September 30, 1991. RODs were signed for approximately 80 of these sites during the fiscal year ending September 30, 1992.

[b] ROD dates are given in fiscal year/quarter format (i.e., 93/1 = October-December of fiscal year 1993). NP reflects those sites listed in CERCLIS that do not have a planned ROD date. Some sites will have multiple RODs. Only first ROD date has been set.

[c] Based on data gathered during site assessments prior to site listing on the NPL. Actual matrices and contaminants that require remediation are determined during later stages of the site evaluation. GW = ground water; VOC = volatile organic compound; BTEX = benzene, toluene; ethylbenzene, and/or xylene; Chlor = chlorinated VOCs; SVOC = Semi-volatile organic compound; PCB = polychlorinated biphenyl; PAH = polynuclear aromatic hydrocarbon; Nonchlor = Non-chlorinated VOCs; NP = Not provided; Pest = pesticide; and Sed = Sediment.

Exhibit A-4: Distribution of Quantities of Contaminated Soil, Sediment, and Sludge at NPL Sites With RODs

Quantity Estimate (Cubic Yards)	Number of NPL Sites with Data By Matrix			Total Sites
	Soil	Sediment	Sludge	
<1,000	34	12	5	51
1,000 - 5,000	49	10	6	65
5,001 - 10,000	33	7	3	43
10,001 - 30,000	55	8	5	68
30,001 - 50,000	32	4	9	45
50,001 - 100,000	19	5	8	32
>100,000	29	3	6	38
Total Number of Sites	251	49	42	342

Note: Data are derived from 342 Records of Decisions (RODs) for 310 sites that have RODs.

Source: U.S. EPA, RODs, fiscal years 1982-1991.

Exhibit A-5: Estimated Quantity of Contaminated Soil, Sediment, and Sludge for Major Contaminant Groups at NPL Sites Without RODs[a]

(1)	(2)	(3)	(4)	(5)
Contaminant Subgroup	**Number of NPL Sites With Available Data[b]**	**Average Based on Available Data (Cubic Yards)[b]**	**NPL Sites Without RODs[c]**	**Projected Total Quantity (Cubic Yards)[d]**
Single:				
Metals	47	75,400	110	8,290,000
VOCs	27	13,700	139	1,900,000
SVOCs	38	27,600	52	1,440,000
Others	8	55,300	18	990,000
Double:				
VOCs & Metals	10	67,000	107	7,170,000
SVOCs & Metals	22	49,200	20	980,000
VOCs & SVOCs	23	23,500	31	730,000
VOCs, SVOCs, & Metals	84	102,400	40	4,100,000
		TOTALS	517	25,600,000

Notes:
[a] Site-specific data are not available for quantities of material to be remediated at sites without Records of Decision (RODs); these values are derived from estimates contained in the RODs for sites containing similar contaminants.
[b] Source of quantity data is U.S. EPA, RODs, fiscal years 1982-1991. Statistical outliers are not included.
[c] Each site is placed in one subgroup only. Contaminant data are not available for 6 of the 523 sites without RODs through fiscal year 1991.
[d] The total for each subgroup is calculated by multiplying columns (3) and (4). Projected quantities are rounded.

Exhibit A-6: Estimated Quantity of Contaminated Soil, Sediment, and Sludge by Sources of Contamination at NPL Sites Without RODs[a]

(1)	(2)	(3)	(4)	(5)
Industrial Sources of Waste[b]	**Number of NPL Sites With Available Data[c]**	**Average Based on Available Data (Cubic Yards)[c]**	**Number of Sites Without RODs[d]**	**Projected Total Quantity (Cubic Yards)[e]**
Primary Metal Products Manufacturing	4	578,400	23	13,300,000
Metal Plating	14	217,000	41	8,900,000
Agricultural Production and Services	11	217,000	27	5,860,000
Fabricated Metal Products Manufacturing	19	64,900	65	4,220,000
Petroleum Refining	16	159,400	16	2,550,000
Inorganic Chemical Manufacturing	22	77,500	32	2,480,000
Organic Chemical Manufacturing	64	31,300	71	2,220,000
Wood Preserving Processes	23	78,600	20	1,570,000
Electronic/Electrical Equipment Manufacturing	16	26,500	41	1,090,000
Used Oil Reclamation	15	44,500	15	670,000

Notes:

a Site-specific data are not available for quantities of material to be remediated at sites without Records of Decision (RODs); these values are derived from ROD estimates for sites containing similar sources of contamination.

b Source of contamination with the highest projected volumes.

c Quantity data is from U.S. EPA, RODs, fiscal years 1982-1991. Each NPL site may have more than one source of contamination. Some quantities are included in more than one calculation of average quantity. Statistical outliers are not included.

d Each NPL site may have more than one source of contamination. Sources available for 446 of the 523 sites without RODs through fiscal year 1991. Some sites are counted under more than one source. Therefore, projected quantities are not additive.

e Calculated by multiplying columns (3) and (4). Because of double counting of sites, projected volumes cannot be totaled. Projected quantities are rounded.

Exhibit A-7: RCRA Facilities by State/Territory

Number of RCRA Treatment, Storage, and Disposal Facilities by State/Territory					
State	**Number**	**State**	**Number**	**State**	**Number**
Alabama	113	Kentucky	138	Ohio	349
Alaska	19	Louisiana	86	Oklahoma	59
Arizona	39	Maine	38	Oregon	51
Arkansas	34	Maryland	52	Pennsylvania	353
California	333	Massachusetts	162	Puerto Rico	57
Colorado	67	Michigan	194	Rhode Island	19
Connecticut	222	Minnesota	54	South Carolina	87
Delaware	20	Mississippi	59	South Dakota	2
Dist. of Columbia	1	Missouri	106	Tennessee	86
Florida	157	Montana	13	Texas	381
Georgia	104	Nebraska	49	Utah	43
Guam	3	Nevada	13	Vermont	5
Hawaii	19	New Hampshire	8	Virgin Islands	1
Idaho	19	New Jersey	170	Virginia	102
Illinois	234	New Mexico	32	Washington	100
Indiana	212	New York	157	West Virginia	51
Iowa	168	North Carolina	122	Wisconsin	62
Kansas	51	North Dakota	9	Wyoming	19

Source: Adapted from RCRIS National Oversight Database, September 5, 1992.

Exhibit A-8: Most Prevalent Wastes Managed at RCRA Solid Waste Management Units Estimated to Need Corrective Action in 1986

Waste Types by Solid Waste Management Unit Type	
LAND DISPOSAL	
Landfills	
Ignitable waste	Tank bottoms (leaded) from petroleum refining
Corrosive waste	Chromium
Lead	Spent halogenated solvents[b]
Wastewater treatment sludge from electroplating[a]	Spent nonhalogenated solvents[c]
Waste containing asbestos	Reactive waste
Waste Piles	
Lead	Cadmium
Barium	Emission control dust/sludge from steel production
Ignitable waste	Chromium
Corrosive waste	Reactive waste
Wastewater treatment sludge from electroplating[a]	API separator sludge from petroleum refining
Surface Impoundments	
Corrosive waste	Chromium
Wastewater treatment sludge from electroplating[a]	API separator sludge from petroleum refining
Ignitable waste	Spent halogenated solvents[b]
Waste oil	Reactive waste
Lead	Dissolved air flotation float from petroleum refining
Land Treatment Units	
Spent nonhalogenated solvents[c]	Silver
API separator sludge from petroleum refining	Waste oil
Ignitable waste	Corrosive waste
Tank bottoms (leaded) from petroleum refining	Slop oil emulsion solids from petroleum refining
Spent halogenated solvents[d]	Dissolved air flotation float from petroleum refining
TREATMENT AND STORAGE	
Container Storage and Accumulation Areas	
Ignitable waste	Spent nonhalogenated solvents[c,e]
Waste oil	Chromium
Corrosive waste	Wastewater treatment sludge from electroplating[a]
Spent halogenated solvents[b,d]	Lead
Tanks and Tank Connections	
Waste oil	Spent nonhalogenated solvents[c,e]
Ignitable waste	Lead
Corrosive waste	Chromium
Spent halogenated solvents[b,d]	Reactive waste
INCINERATION	
Ignitable waste	Reactive waste
Spent nonhalogenated solvents[c,e]	Hydrocyanic acid
Corrosive waste	Phenol
Waste oil	Benzene
Spent halogenated solvents[b,d]	

Exhibit A-8 (Continued)

Waste Types by Solid Waste Management Unit Type

MISCELLANEOUS

Boilers

Waste oil	Waste containing 50-500 ppm polychlorinated biphenyls
Ignitable waste	Wastewater treatment sludge from electroplating[a]
Spent nonhalogenated solvents[c,e]	Electroplating residues where cyanides are used
Spent halogenated solvents[b]	Methylene oxide
Formaldehyde	

Furnaces

Mercury	Propylene dichloride
Waste oil	1,2-Dichloropropane
Ignitable waste	Cresylic acid
Decanter tank tar sludge from coking operations	Cresols
Propane,2,2'-oxybis(2-chloro-)	Reactive waste
Bis(2-chloroisopropyl) ether	Lead

Other Miscellaneous Units

Ignitable waste	Reactive waste
Corrosive waste	Chromium
Spent halogenated solvents[b,d]	Cadmium
Waste oil	Lead
Spent nonhalogenated solvents[c]	

UNKNOWN

Wastewater treatment sludge from electroplating[a]	Phenol
Lead	Benzene
Corrosive waste	Waste containing asbestos
Ignitable waste	Hazardous wastewater treatment liquid

Notes:

[a] RCRA Waste Code F006: Wastewater treatment sludges from certain electroplating operations except from the following processes: (1) Sulfuric acid anodizing of aluminum; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminum or zinc-aluminum plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminum plating on carbon steel; and (6) chemical etching and milling of aluminum.

[b] RCRA Waste Code F001: The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride and chlorinated fluorocarbons and all spent solvent mixtures/blends used in degreasing containing before use a total of 10% or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005, and still bottoms from the recovery of these spent solvents and spent solvent mixtures.

[c] RCRA Waste Code F003: The following spent nonhalogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol; all spent solvent mixtures/blends containing, before use, only the above spent nonhalogenated solvents; and all spent solvent mixtures/blends containing before use one or more of the above nonhalogenated solvents, and a total of 10% or more (by volume) of one or more of those solvents listed in F001, F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.

[d] RCRA Waste Code F002: The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane, and 1,1,2-trichloroethane, ortho-dichlorobenzene, and trichlorofluoromethane; all spent solvent mixtures/blends containing before use a total of 10% or more (by volume) of one or more of those solvents listed in F001, F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.

[e] RCRA Waste Code F005: The following spent nonhalogenated solvents: cresols and cresylic acid, and nitrobenzene; and the still bottoms from the recovery of these solvents; all spent solvent mixtures/blends containing before use a total of 10% or more (by volume) of one or more of the above nonhalogenated solvents or those solvents listed in F001, F002, or F004; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.

Source: Adapted from 1986 TSDR/GENSUR data.

Exhibit A-9: Location of Registered USTs in the United States

Region	State	Number of Tanks	Number of Confirmed Releases	Cleanups Initiated or Completed
One	CT	34,792	1,287	1,258
	MA	24,825	3,406	2,883
	ME	17,134	924	896
	NH	13,366	575	575
	RI	6,264	345	345
	VT	4,236	907	907
	Subtotal	100,617	7,444	6,864
Two	NJ	51,558	4,094	2,981
	NY	51,006	7,807	7,737
	PR	6,555	125	124
	VI	280	13	12
	Subtotal	109,399	12,039	10,854
Three	DC	5,041	356	269
	DE	6,492	1,229	939
	MD	21,659	9,798	7,965
	PA	66,289	2,988	2,231
	VA	52,648	3,467	1,777
	WV	17,939	803	446
	Subtotal	170,068	18,641	13,627
Four	AL	31,271	1,547	963
	FL	57,615	11,020	4,515
	GA	51,233	2,002	1,421
	KY	34,133	2,642	2,608
	MS	17,181	521	427
	NC	60,309	13,272	12,575
	SC	26,295	2,870	414
	TN	44,243	5,050	4,344
	Subtotal	322,280	38,924	27,267
Five	IL	63,922	8,422	7,110
	IN	29,227	2,963	1,364
	MI	69,133	7,296	6,944
	MN	33,033	3,739	2,978
	OH	74,959	10,406	9,144
	WI	67,281	6,719	6,074
	Subtotal	337,555	39,545	33,614

Exhibit A-9: Location of Registered USTs in the United States (Continued)

Region	State	Number of Tanks	Number of Confirmed Releases	Cleanups Initiated or Completed
Six	AR	16,030	296	236
	LA	25,265	1,407	650
	NM	8,411	1,147	690
	OK	29,384	1,246	408
	TX	104,366	12,473	7,907
	Subtotal	183,456	16,569	9,891
Seven	IA	15,904	4,325	815
	KS	15,331	2,806	2,508
	MO	20,443	2,121	1,812
	NE	10,859	1,837	260
	Subtotal	62,537	11,089	5,395
Eight	CO	22,246	2,425	1,562
	MT	12,828	1,118	904
	ND	8,030	474	426
	SD	8,325	1,226	1,015
	UT	10,299	1,558	1,089
	WY	8,217	1,038	478
	Subtotal	69,945	7,839	5,474
Nine	AZ	18,540	2,270	1,679
	CA	124,872	21,127	7,923
	HI	5,618	464	205
	NV	5,986	1,131	863
	CQ	89	2	2
	GU	433	70	70
	SA	53	2	2
	Subtotal	155,591	25,066	10,744
Ten	AK	5,847	611	417
	ID	8,493	561	460
	OR	16,105	3,535	2,071
	WA	23,720	2,594	2,396
	Subtotal	54,165	7,301	5,344
Nation-Wide	TOTAL	1,565,613	184,457	129,074

Source: EPA, Office of Underground Storage Tanks, Fourth Quarter 1992.

Exhibit A-10: Types of DOD Sites

Site Category	Definition
Aboveground Storage Tank	Liquid storage tanks and connected piping, from which a release has occurred and which can be inspected on all sides.
Burn Area	Area consisting of pits or on the surface where combustible materials have been burned. Areas used to burn material for the purpose of fire fighting training or to burn ordnance are not included in this type. Contaminants often found include: volatile organic chemicals (VOCs) and polychlorinated biphenyls (PCBs).
Contaminated Buildings	Buildings or structures contaminated with substances including, but not limited to: asbestos, dioxins, explosives, heavy metals, low-level radioactive waste, organic solvents, pesticides, PCBs, and other chemicals.
Contaminated Ground Water	Ground water for which the source of contamination cannot be identified or for which there is more than one source of contamination.
Contaminated Sediments	Sediments of bodies of water (except surface impoundments) that have been contaminated by surface runoff, sub-surface migration, or direct discharge of contaminants. Typical soil contaminants are: oil, grease, phenols, and toluene.
Disposal Pit/Dry Well	Unlined pit or dry well where uncontained wastes have been discharged for disposal.
Explosive Ordnance Disposal	Area used to burn, detonate, bury, or dispose of explosive ordnance.
Fire/Crash Training Area	Area used for fire fighting training where waste oils, fuels, and other flammable liquids have been burned and extinguished with water and/or fire fighting chemicals.
Landfill	Lined or unlined trench, pit, or other excavation area into which wastes have been placed and periodically covered with soil and which may or may not include leachate collection systems.
Oil-Water Separator	Oil-water separator, associated piping, and adjacent area.
POL (petroleum, oil, & lubricants) Line	Distribution lines used to transport POL products from storage to dispensing facilities; not including piping connected directly to tanks or dispensing facility.
Radioactive Waste	Site used for storage or disposal of low-level radioactive waste.
Spill Area	Site at which accidental or sporadic releases of hazardous wastes have occurred.
Storage Area	Site used to store containerized waste.
Surface Disposal Area	Area of limited or no excavation where wastes have been placed but have not been covered with soil.
Surface Impoundment/ Lagoon	Lined pit or lagoon where uncontained liquid wastes have been discharged for disposal.
Underground Storage Tank Area	Liquid storage tanks that cannot be inspected on all sides and from which a release has occurred. Includes connected piping.
Unexploded Munitions/ Ordnance Area	Area, primarily firing ranges, that contains unexploded ordnance.
Waste Line	Pipeline used to transport sanitary or industrial wastes.
Waste Treatment Plant	Municipal or industrial waste water treatment plant.

Sources:
DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Installation Restoration Program Cost Estimate*, September 1991.
DOD, Office of the Deputy Assistant Secretary of Defense (Environment), *Defense Environmental Restoration Program Management Information System (DERPMIS): Information Paper*, (CETHA-IR-P), March 1992.

Exhibit A-11: Most Frequently Reported Contaminant Types by DOD Site Category (Percents refer to frequency of sites containing the contaminant)[a]

Site Type[b]	Air Force Contaminants	%	Army Contaminants	%	Navy Contaminants	%
Aboveground Storage Tanks	POLs	85	POLs	69	POLs	79
	Industrial Wastewater	5	POL Sludge	25	Paints	14
	Propellant	5	Acids	6	PCBs	14
	Other	10	Bases	6	Solvents	14
			Explosive Chemicals	6	Other	7
			Industrial Liquid Waste	6		
			Unexploded Ordnance	6		
			Other	6		
Burn Areas	POLs	38	Ordnance Components	44	POLs	41
	Propellant	19	Heavy Metals	35	Solvents	38
	Refuse without HW	19	Explosive Chemicals	18	Paints	16
	Solvents	19	Other	43	Other	16
	Other	44				
Contaminated Building	None		POLs	27	Pesticides	20
			Propellant	23	Acids	13
			POL Sludge	20	Asbestos	13
			Other	35	Heavy Metals	13
					Plating Waste	13
					PCBs	13
					Solvents	13
					Other	33
Contaminated Fill	Chemical Agents	33	Ordnance Components	64	POLs	56
	Dredge Spoils	33	Ash	55	Blasting Grit	33
	Heavy Metals	33	Explosive Chemicals	54	Heavy Metals	33
	POLs	33	Other	9	Paints	33
	Other	33				

Exhibit A-11: Most Frequently Reported Contaminant Types by DOD Site Category (Continued)

Site Type[b]	Air Force Contaminants	%	Army Contaminants	%	Navy Contaminants	%
Contaminated Ground Water	POLs	60	Chlorinated Solvents	69	Chlorinated Solvents	60
	Chlorinated Solvents	20	Heavy Metals	38	Non-chlorinated Solvents	40
	Solvents	20	Explosive Chemicals	23	Acids	20
	Other	20	Other	8	Heavy Metals	20
					POLs	20
					Refuse without HW	20
					Other	20
Contaminated Sediments	POLs	36	Heavy Metals	63	Heavy Metals	58
	Solvents	20	Pesticides	38	POLs	36
	Paints	8	Explosive Chemicals	25	Industrial Wastewater	21
	Other	44	Other	31	Solvents	21
					Other	36
Disposal Pit/Dry Well	POLs	35	Ordnance Components	27	POLs	42
	Solvents	34	Heavy Metals	24	Solvents	23
	Acids	9	Chlorinated Solvents	14	POL Sludge	13
	Industrial Sludge	9	Other	47	Other	38
	Other	29				
Explosive Ordnance Disposal Area	Unexploded Ordnance	60	Heavy Metals	47	Explosive Chemicals	32
	Ordnance Components	40	Ordnance Components	44	Ordnance Components	26
	Explosive Chemicals	20	Explosive Chemicals	42	Unexploded Ordnance	26
	Scrap Metal	20	Other	40	Other	5
Fire/Crash Training Area	POLs	72	POLs	90	POLs	91
	Solvents	30	POL Sludge	30	Solvents	34
	Chemical Agents	4	Solvents	30	Heavy Metals	9
	Other	25	Other	20	Paints	9
					Other	6
Landfill	Refuse with HW	29	Heavy Metals	18	POLs	34
	Refuse without HW	21	Ordnance Components	13	Solvents	34
	POLs	18	Refuse without HW	12	Paints	29
	Other	40	Other	87	Other	24

Exhibit A-11: Most Frequently Reported Contaminant Types by DOD Site Category (Continued)

Site Type[b]	Air Force Contaminants	%	Army Contaminants	%	Navy Contaminants	%
Oil Water Separator	POLs	63	POLs	86	POLs	100
	Heavy Metals	5	Solvents	71	Industrial Wastewater	33
	Industrial Wastewater	5	Chlorinated Solvents	14	Solvents	33
	Solvents	5	Industrial Wastewater	14		
	Other	32	Plating Waste	14		
			Other	14		
POL Lines	POLs	100	POL Sludge	100	POLs	100
Radioactive Waste	Low Level Radiation	46	Low Level Radiation	100	Low Level Radiation	100
	Other	54	Other	100		
Spill Site Area	POLs	60	Heavy Metals	34	POLs	56
	Solvents	5	POLs	24	PCBs	18
	PCBs	4	Ordnance Components	21	Solvents	18
	Other	35	Other	52	Other	19
Storage Area	POLs	40	Heavy Metals	22	POLs	34
	Solvents	10	POLs	18	PCBs	31
	PCBs	7	Pesticides	15	Solvents	28
	Other	50	Other	42	Other	15
Surface Disposal Area	POLs	39	Heavy Metals	29	POLs	34
	Solvents	19	Dredge Spoils	22	Solvents	22
	Pesticides	8	Pesticides	12	Paints	15
	Other	28	Other	56	Other	19
Surface Impoundment/Lagoon	POLs	36	Heavy Metals	35	POLs	33
	Solvents	28	Ordnance Components	30	Heavy Metals	19
	Industrial Wastewater	24	Explosive Chemicals	17	Solvents	19
	Other	16	Pesticides	17	Other	30
			Other	53		
Underground Storage Tanks	POLs	50	POLs	75	POLs	57
	Solvents	4	POL Sludge	45	Solvents	16
	Heavy Metals	2	Heavy Metals	10	Chlorinated Solvents	10
	Plating Waste	2	Other	13	Other	16
	Other	46				

Exhibit A-11: Most Frequently Reported Contaminant Types by DOD Site Category (Continued)

Site Type[b]	Air Force Contaminants	%	Army Contaminants	%	Navy Contaminants	%
Unexploded Munitions/Ordnance Area	Unexploded Ordnance	100	Unexploded Ordnance	87	Ordnance Components	75
			Ordnance Components	40	Explosive Chemicals	50
			Scrap Metal	35	Heavy Metals	50
			Other	20		
Waste Lines	Other	100	Heavy Metals	62	Solvents	33
			Pesticides	35	Heavy Metals	27
			Explosive Chemicals	19	Industrial Wastewater	27
			Other	23	Other	13
Waste Treatment Plant	Industrial Sludge	28	Heavy Metals	26	Heavy Metals	75
	Heavy Metals	22	POLs	11	Industrial Sludge	50
	POLs	6	Industrial Liquid Waste	9	Industrial Wastewater	25
	Other	67	Ordnance Components	9	Pesticides	25
			Other	60	POLs	25
Other & Unidentified[c]	POLs	3	Inert Material	21	Heavy Metals	11
	Other	95	Ash	10	POLs	6
			Ordnance Components	9	Acids	5
			Other	43	PCBs	4
					Refuse without HW	5
					Solvents	5
					Other	71

Notes:

[a] The percentages reflect the number of sites where a contaminant is identified relative to the number of sites reporting. The percent totals are often greater than 100 because most sites contain more than one type of contaminant. Other includes contaminants labelled "other," "unknown," or "unspecified" in the DERPMIS system.

[b] The definitions of the site types appear in Exhibit A-10.

[c] The "other & unidentified" category includes sites that do not match the classification system used for the database.

Source: DOD, Analysis from the Defense Environmental Restoration Program Management Information System, June 1992, provided by DERP.

Exhibit A-12: DOE Installations/Sites Where Cleanup Is In Progress[a]

State	Installation/Site	Program Information	Contaminated Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Volume To Be Remediated (Cu.Yards)	Estimated Cost FY 94-98 (millions)
AZ	Monument	UMTRA	Soil, Ground Water	Radon, Radon "Daughters"	983,300	b
	Tuba City	UMTRA — Remediation completed				
CA	General Atomics	D&D — Decommissioning in progress				
	General Electric Vallecitos Nuclear Center	D&D — Decommissioning in progress				
	University of California	FUSRAP — Remediation completed				
CO	Durango	UMTRA — Remediation completed				
	Grand Junction	UMTRA	Soil, Ground Water, Masonry	Radon, Radon "Daughters"	5.2 million	b
	Gunnison	UMTRA	Soil	Radon, Radon "Daughters"	720,000	b
	Rifle	UMTRA	Soil, Ground Water	Radon, Radon "Daughters"	3.8 million	b
ID	Lowman	UMTRA — Remediation completed				
IL	Fermi National Accelerator Laboratory		Soil, Masonry	Chromate, PCBs	Unknown	$21.6[c]
	National Guard Armory	FUSRAP — Remediation completed				
	Site A/Plot M (Cook County)	D&D — Surveillance and Maintenance Ongoing				
	University of Chicago	FUSRAP — Remediation completed				

Exhibit A-12: DOE Installations/Sites Where Cleanup Is In Progress (Continued)

State	Installation/Site	Program Information	Contaminated Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Volume To Be Remediated (Cu.Yards)	Estimated Cost FY 94-98 (millions)
MA	Ventron	FUSRAP	Soil, Masonry	U, Pb, Th, Ra, PCBs	7,000	d
MO	Hazelwood (Latty Avenue)	on NPL, FUSRAP	Soil, Masonry	U, Ra, Th, Pb, PCBs	211,000	d
MT	Component Development and Integration Facility		Site of a demonstration of plasma arc vitrification technology involving cleanup of metals and organics in soil and sludge			
NE	Hallam Nuclear Power Facility	D&D — Surveillance and maintenance ongoing				
NJ	Kellex/Pierpont	FUSRAP — Remediation completed				
	Middlesex Sampling Plant	FUSRAP	Soil, Masonry	Th, U, Ra, Pb, PCBs	57,200	d
	Middlesex Municipal Landfill	FUSRAP — Remediation completed				
NM	Acid/Pueblo Canyon	FUSRAP — Remediation completed				
	Ambrosia Lake	UMTRA	Soil, Ground Water	Radon, Radon "Daughters"	2.6 million	b
	Bayo Canyon	FUSRAP — Remediation completed				
	Chupadera Mesa	FUSRAP — Remediation completed				
	Shiprock	UMTRA — Remediation completed				
	Waste Isolation Pilot Plant	Ongoing waste management program involving radioactive transuranic waste				

Exhibit A-12: DOE Installations/Sites Where Cleanup Is In Progress (Continued)

State	Installation/Site	Program Information	Contaminated Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Volume To Be Remediated (Cu.Yards)	Estimated Cost FY 94-98 (millions)
NY	Baker-Williams Warehouse	FUSRAP	Masonry			d
	Niagara Falls Storage Site Vicinity Properties	FUSRAP — Remediation completed				
	West Valley Demonstration Project	Waste Management Program demonstration involving high-level radioactive waste solidification; D&D activities also ongoing				
OH	Battelle Columbus Laboratories	D&D — Decommissioning in progress				
	Piqua Nuclear Power Facility	D&D — Surveillance and maintenance ongoing				
OR	Albany Metallurgical Research Center	FUSRAP — Remediation completed				
	Lakeview	UMTRA — Remediation completed				
PA	Canonsburg	UMTRA — Remediation completed				
	Aliquippa Forge	FUSRAP	Soil, Masonry	U, Th, Ra, Pb, PCBs	38	d
SD	Edgemont	UMTRA	Soil	Radon, Radon "Daughters"		b
TN	Elza Gate	FUSRAP	Soil, Masonry	U, Ra, Th, Pb, PCBs	4,379	d
TX	Falls City	UMTRA	Soil, Ground Water	Radon, Radon "Daughters"	5.8 million	b
UT	Green River	UMTRA — Remediation completed				
	Mexican Hat	UMTRA	Soil, Ground Water	Radon, Radon "Daughters"	2.7 million	b

Exhibit A-12: DOE Installations/Sites Where Cleanup Is In Progress (Continued)

State	Installation/Site	Program Information	Contaminated Matrices of Concern	Examples of Known Soil Contaminants	Estimated Soil Volume To Be Remediated (Cu.Yards)	Estimated Cost FY 94-98 (millions)
UT	Salt Lake City	UMTRA — Remediation completed				
WY	Riverton	UMTRA — Remediation completed				
	Spook	UMTRA — Remediation completed				

Definitions:
UMTRA: Uranium Mill Tailings Remedial Action Project site
D&D: Decontamination and Decommissioning Program site
NPL: Listed on the Superfund National Priorities List
FUSRAP: Formerly Utilized Site Remedial Action Program site

Notes:

[a] Information in this table is a compilation of data from the following sources:
- U.S. Department of Energy, 1993, Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998, DOE/S00097P Vol II.
- U.S. Department of Energy, 1991, Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1993-1997 (DOE/S-0090P).
- Telephone interviews with appropriate DOE Field Office personnel and/or contractors.
- U.S. Department of Energy, 1991, Technology Needs Assessment Final Report (DOE/ID/12584-92 Vol. 1).
- U.S. Department of Energy, 1991, Technology Needs Assessment Final Report: Appendices A-J (DOE/ID/12584-92 Vol. 2).
- U.S. Department of Energy, Undated, Uranium Mill Tailings Remedial Action (brochure).
- Jacobs Engineering Group, Inc., 1991, UMTRA Questions and Answers (fact sheet).
- Jacobs Engineering Group, Inc., 1991, UMTRA Fact Sheet (fact sheets are specific to each UMTRA site).
- Records of Decision signed for some DOE sites.
- Bechtel National, Inc., 1991, Volume Register for FUSRAP and SFMP Sites.

[b] DOE's total validated estimate for environmental restoration work at UMTRA sites and vicinity properties for Fiscal Years 1994-1998 is $250.0 million. Site-by-site estimates were not included in the agency's Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998 (DOE/S00097P Vol I and Vol II).

[c] This allocation includes funding for activities at Ames Laboratory (IA), Fermi National Accelerator Laboratory (IL), and Princeton Plasma Physics Laboratory (NJ).

[d] DOE's total validated estimate for environmental restoration work at FUSRAP sites for Fiscal Years 1994-1998 is $456.7 million. Site-by-site estimates were not included in the agency's Environmental Restoration and Waste Management Five-Year Plan: Fiscal Years 1994-1998 (DOE/S00097P Vol I and Vol II).

APPENDIX B
FEDERAL AND STATE AGENCY PROGRAMS

DEPARTMENT OF DEFENSE

U.S. Air Force

Air Combat Command
HQ ACC/CEV
Langley AFB, VA 23665-5001
Col. John Mogge
804-764-2801

Air Force Reserve
HQ AFRES/CEPV
Robins AFB, GA 31098-6001
Mr. Robert Akridge
912-327-1072

Air Training Command
HQ ATC/DEV
Randolph AFB, TX 7815-5001
Col. Richard Kochanek
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U.S. Air Force Academy
HQ USAFA/DEP
Colorado Springs, CO 80840-5546
Maj. Douglas Sherwood
719-472-4483

Air Force District of Washington
HQ AFDW/CEV
Bolling AFB, DC 20332
Capt. William Buckingham
202-767-1160

Air Force Space Command
HQ AFSPACECOM/CEV
Peterson AFB, CO 80914-5001
Mr. Gary Maher
719-554-5187

Air University
HQ AU/CEV
Maxwell AFB, AL 36112-5001
Mr. James Rumbley
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U.S. Air Forces Europe
HQ USAFE/DEP
Ramstein AB, GE
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Lt. Col. Jay Carson

Air Force Material Command
HQ AFMC/CEV
Wright-Patterson AFB, OH 45433-5000
Col. Tom Walker
513-257-5873

Air Mobility Command
HQ AMC/CEV
Scott AFB, IL 62225-5001
Col. Jacob Dustin
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Pacific Air Force
HQ PACAF/DEV
Hickam AFB HI 96853-5001
Col. Russ Marshall
808-449-5151

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Mr. Ron Watson
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Air Force Human Systems Center
HSC/EN
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HQ Naval Facilities Engineering Command
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Air Force Base Disposal Agency
AFBDA/BD
Washington, DC 20330
Col. David Cannan
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Air Force Civil Engineering Support Agency
AFCES/EN
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Air Force Center for Environmental Excellence
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P.O. Box 5400
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U.S. EPA - Region 3
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U.S. EPA - Region 4
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230 South Dearborn
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U.S. EPA - Region 7
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999 18th Street, Suite 1300
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303-293-1603

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OTHER FEDERAL AGENCIES

Department of Agriculture

Forest Service
Environmental Issues
201 14th Street, SW
Washington, DC 20250
202-205-0957

Agricultural Research Services
Facilities Division
Safety, Health, and Environmental Management Branch
6303 Ivy Lane
Greenbelt, MD 20770-1433
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Commodity Credit Corporation
Conservation and Environmental Protection Division
Post Office Box 2415
Washington, DC 20013
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Farmers Home Administration/Rural Development Administration
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14th & Independence, Room 6309
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Department of Commerce

U.S. Department of Commerce
Office of Management Support
Environmental Safety & Compliance Division
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General Services Administration

General Services Administration
Safety & Environmental Management Division
Environmental Branch (PMS)
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Department of the Interior

Bureau of Land Management
Public Affairs
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202-208-3435

Bureau of Mines
Division of Environmental Technology
810 7th Street, NW, Mail Stop 6205
Washington, DC 20241
202-501-9271

Bureau of Reclamation
Public Affairs Office
Department of the Interior
1849 C Street, NW
Washington, DC 20240-9000
202-208-4662

National Park Service
Environmental Quality Division
1849 C Street, NW, Room 1210
Washington, DC 20240
202-208-3163

Fish & Wildlife Service
1849 C Street, NW, Room 3447
Washington, DC 20240
202-208-5634

Department of Justice

U.S. Department of Justice
Public Affairs, Room 1216
10th & Constitution Ave., NW
Washington, DC 20530
202-514-2007

National Aeronautics and Space Administration

NASA Headquarters
Environmental Affairs
Washington, DC 20546
202-358-1090

Small Business Administration

Small Business Administration
Office of Litigation, 7th Floor
409 3rd Street, SW
Washington, DC 20416
202-205-6643

Tennessee Valley Authority

Tennessee Valley Authority
Environmental Quality Staff
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Knoxville, TN 37902
615-632-6578

U.S. Department of Transportation

Federal Aviation Administration
Office of Environment and Energy (AEE-20)
800 Independence Ave., SW
Washington, DC 20591
202-267-3554

U.S. Coast Guard
Environmental Affairs
2100 2nd Street, SW
Washington, DC 20593
202-267-1587

STATE SOLID AND HAZARDOUS WASTE AGENCIES

Alabama
Land Division
Alabama Department of Environmental Management
1751 Congressman W.L. Dickinson Drive
Montgomery, AL 36130
205-271-7730

Alaska
Solid and Hazardous Waste Management Section
Division of Environmental Quality
Department of Environmental Conservation
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Juneau, AK 99811-1800
907-465-2671

Arizona
Office of Waste Programs
Arizona Department of Environmental Quality
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Arkansas
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Little Rock, AR 72219
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California Integrated Waste Management Board
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Sacramento, CA 95814
916-327-1550

Colorado
Hazardous Materials and Waste Management Division
Colorado Department of Health
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Denver, CO 80220
303-331-4830

Connecticut
Bureau of Waste Management
Connecticut Department of Environmental Protection
165 Capitol Avenue
Hartford, CT 06106
203-566-8476

Delaware
Division of Air and Water Management Department
Natural Resources and Environmental Control
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Dover, DE 19903
302-739-4764

District of Columbia
Pesticides and Hazardous Materials Division
Office of Consumer and Regulatory Affairs
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Washington, DC 20032
202-404-1167 or 727-4821

Florida
Division of Waste Management
Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, FL 32399
904-487-3299

Georgia
Land Protection Branch
Environmental Protection Division
Department of Natural Resources
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Atlanta, GA 30334
404-656-2833

Hawaii
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Hawaii Department of Health
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500 Ala Moana, Suite 250
Honolulu, HI 96813
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Idaho
Hazardous Materials Bureau
Water Quality Bureau
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Illinois
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Illinois Environmental Protection Agency
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Hazardous Waste Management
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105 South Meridian Street
Indianapolis, IN 46206-6015
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Iowa
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Des Moines, IA 50319-0034
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Kansas
Bureau of Air and Waste Management
Department of Health and Environment
Forbes Field, Building 740
Topeka, KS 66620
913-296-1593

Kentucky
Division of Waste Management
Department of Environmental Protection
18 Reilly Road
Frankfort, KY 40601
502-564-6716

Louisiana
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Baton Rouge, LA 70884
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Maine
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Department of Natural Resources
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APPENDIX C
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Department of Energy Sites (DOE)

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APPENDIX D
DEFINITIONS OF TERMS AND ACRONYMS

DEFINITIONS OF INNOVATIVE TECHNOLOGIES SELECTED FOR NPL SITE CLEANUPS

***Ex Situ* Bioremediation**
This technology uses microorganisms to degrade organic contaminants in excavated soil, sludge, and solids. The microorganisms break down the contaminants by using them as a food source. The end products are typically CO_2 and H_2O. *Ex situ* bioremediation includes slurry-phase bioremediation, in which the soils are mixed in water to form a slurry, and solid-phase bioremediation, where the soils are placed in an enclosure, aerated, and periodically mixed with water and nutrients. Variations of the latter are called land farming or composting.

***In Situ* Bioremediation**
With *in situ* bioremediation, nutrients, an oxygen source, and sometimes microbes are pumped into the soil or aquifer under pressure through wells or spread on the surface for infiltration to the contaminated material.

Chemical Treatment
In chemical treatment, contaminants are converted to less hazardous compounds through chemical reactions. Chemical treatment has been used five times in the Superfund program, usually to reduce a contaminant (hexavalent chromium to the trivalent form) or oxidize a contaminant (cyanide, for example). Neutralization is considered to be an available technology and is not included in this report.

Dechlorination
Dechlorination results in the removal or replacement of chlorine atoms bonded to hazardous compounds.

***In Situ* Flushing**
For *in situ* flushing, large volumes of water at times supplemented with treatment compounds, are introduced to the soil, waste, or ground water to flush hazardous contaminants from a site. This technology is predicated on the assumption that the injected water can be effectively isolated within the aquifer and recovered.

***In Situ* Vitrification**
This technology treats contaminated soil in place at temperatures of approximately 3000°F (1600°C). Metals are encapsulated in the glass-like structure of the melted silicate compounds. Organics may be treated by combustion.

Soil Washing
Soil washing is used for two purposes. First, the mechanical action and water (sometimes with additives) physically remove contaminants from soil particles. Second, the agitation of the soil particles allows the smaller diameter, more highly contaminated fines to separate from the larger soil particles, thus reducing the volume of material for subsequent treatment.

Solvent Extraction
Solvent extraction operates on the principle that organic contaminants can be preferentially solubilized and removed from the waste using the correct solvent. The solvent to be used will vary depending on the waste to be treated.

Thermal Desorption

For thermal desorption, the waste is heated in a controlled environment to cause organic compounds to volatilize from the waste. The operating temperature for thermal desorption is less than 1000°F (550°C). The volatilized contaminants will usually require further control or treatment.

Soil Vapor Extraction

This technology removes volatile organic constituents from the subsurface through the use of vapor extraction wells, sometimes combined with air injection wells, to strip and flush the contaminants into the air stream for further treatment.

Other Technologies

Other technologies include air sparging and the contained recovery of oily wastes (CROW) technologies. Air sparging involves injecting gas into the aquifer to draw off contaminants as they percolate up through the ground water and capturing them with a vapor extraction system. The CROW process displaces oily wastes with steam and hot water. The contaminated oils and ground water move into a more permeable area and are pumped out of the aquifer.

DESCRIPTIONS OF CATEGORIES OF INDUSTRIAL SOURCES OF WASTE

Section 3.4.2 describes the most prevalent industrial activities that contributed to the contamination at the 523 NPL sites without RODs. The following are descriptions of the general types of activities that typically occur within each industry group. These descriptions are based on the *Standard Industrial Classification (SIC) Manual, 1987*, published by the U.S. Department of Commerce, Bureau of the Census. Each industry described is a broad group, only part of which may pertain to a particular NPL site.

Agriculture

Establishments primarily engaged in agricultural production, forestry, commercial fishing, hunting, and trapping, and related services. Specifically, the agriculture component includes:

- Agricultural production, crops: grains, fruits, nuts, vegetables.
- Agricultural production, livestock: livestock, poultry, eggs.
- Agricultural services: soil preparation, crop services.

Electronic/Electrical Equipment Manufacture

Establishments engaged in manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and use of electrical energy. Specifically, electric transmission and distribution equipment; household appliances; electrical industrial apparatus; electric lighting and wiring equipment; household audio and video equipment; communications equipment; electronic components and accessories; and miscellaneous electrical machinery, equipment, and supplies.

Fabricated Metal Products

Establishments engaged in fabricating ferrous and nonferrous metal products. This includes metal cans and shipping containers; cutlery, hand tools, general hardware; nonelectric heating apparatus; fabricated structural metal products; screws, nuts, bolt; metal forgings and stampings; coating and engraving; and miscellaneous fabricated metal products.

Inorganic Chemicals

Establishments primarily engaged in manufacturing basic inorganic chemicals, including alkalies and chlorine, industrial gases, inorganic pigments, and industrial inorganic chemicals (not elsewhere classified), but does not include pesticides, medicines, soaps, or drugs.

Organic Chemicals

Establishments primarily engaged in manufacturing industrial organic chemicals, including gum and wood chemicals; cyclic organic crudes and intermediates, organic dyes and pigments; and industrial organic chemicals (not elsewhere classified).

Other Manufacturing

Establishments primarily engaged in manufacturing products not classified in any other major manufacturing group, including jewelry, silverware, and plated ware; musical instruments; dolls, toys, games, and sporting and athletic goods; pens, pencils, and other artists' materials; costume jewelry, novelties, buttons, and miscellaneous notions; and miscellaneous manufacturing industries.

Others

Establishments that do not fall under other categories.

Paints and Coatings

Establishments primarily engaged in manufacturing paints; varnishes; lacquers; enamels and shellac; putties, wood fillers, and sealers; paint and varnish removers; paint brush cleaners; and allied paint products.

Petroleum Refining	Establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials. Specifically, those establishments engaged in petroleum refining, asphalt paving and roofing materials, and miscellaneous products of petroleum and coal. Does not include establishments engaged in manufacturing and distributing gas to consumers, or those engaged in producing coke and coke byproducts.
Plating	Establishments primarily engaged in all types of electroplating, plating, anodizing, coloring, and finishing of metals and formed products for the trade. Also included are establishments that perform these types of activities, on their own account, on purchased metals or formed products.
Primary Metal Products	Establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap; in rolling, drawing, and alloying metals; in manufacturing castings and other basic metal products; and in manufacturing nails, spikes, and insulated wire and cable, including steel works, blast furnaces, and rolling and finishing mills; iron and steel foundries; primary smelting and refining of nonferrous metals; secondary smelting and refining of nonferrous metals; rolling, drawing, and extruding of nonferrous metals; nonferrous foundries (castings); and miscellaneous primary metal products.
Rubber and Plastics Products	Establishments manufacturing products, not elsewhere classified, from plastics and resins, and from natural, synthetic, or reclaimed rubber, gutta percha, balata, or gutta siak. Does not include recapping and retreading of automobile tires, or manufacturing of synthetic rubber or synthetic plastics resins, including tires and inner tubes; rubber and plastics footwear; gaskets, packing, and sealing devices and rubber and plastics hose and belting, fabricated rubber products (not elsewhere classified); and miscellaneous plastics products.
Solvent Reclamation	Establishments engaged in chlorinated and/or nonchlorinated solvent recovery services on a contract or fee basis.
Used Oil Reclamation	Establishments primarily engaged in blending, compounding, and re-refining lubricating oils and greases from purchased mineral, animal, and vegetable materials.
Wood Preserving	Establishments primarily engaged in treating wood, sawed or planed in other establishments, with creosote or other preservatives to prevent decay and to protect against fire and insects. Also includes the cutting, treating, and selling of poles, posts, and piling.

ACRONYMS

ATTIC	Alternative Treatment Technology Information Center
BLM	Bureau of Land Management
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CA	Cooperative Agreement
CA	RCRA Corrective Action
CAMU	RCRA Corrective Action Management Unit
CBO	Congressional Budget Office
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CMI	RCRA Corrective Measures Implementation
CMS	RCRA Corrective Measures Study
CORA	Cost of Remedial Action Computer Model
CRDA	Cooperative Research and Development Agreement [DOE]
D&D	Decontamination and Decommissioning
DERA	Defense Environmental Restoration Account
DERP	Defense Environmental Restoration Program
DERPMIS	Defense Environmental Restoration Program Management Information System
DLA	Defense Logistics Agency
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	Department of Interior
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERCS	Emergency Remedial Contracting Strategy
ERMC	Environmental Restoration Management Contractor [DOE]
FR	Federal Register
FUDS	Formerly Used Defense Sites
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal Year
GAO	U.S. Government Accounting Office
GENSUR	National Survey of Hazardous Waste Generators
HRS	Superfund Hazard Ranking System
HSWA	Hazardous and Solid Waste Amendments of 1984
IAG	Interagency Agreement
IRP	Defense Installation Restoration Program
LDR	RCRA Land Disposal Restrictions
NAPL	Nonaqueous Phase Liquid
NAVFAC	Navy Facilities Engineering Command
NCAPS	National Corrective Action Priority Ranking System
NCEPI	National Center for Environmental Publications and Information
NCP	National Oil and Hazardous Substances Contingency Plan
NPL	Superfund National Priorities List of Hazardous Waste Sites
O&M	Operation and Maintenance
ORD	Office of Research and Development
OSW	Office of Solid Waste
OSWER	Office of Solid Waste and Emergency Response
OTA	Office of Technology Assessment

PA	Preliminary Site Assessment
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCE	Perchloroethylene
PRDA	Program Research and Development Announcement [DOE]
PEIS	Programmatic Environmental Impact Statement [DOE]
POL	Petroleum, Oil, and Lubricants
POTW	Publicly Owned [wastewater] Treatment Works
PRP	Potentially Responsible Party
RA	Remedial Action
RAC	Remedial Action Contractor
RACS	Remedial Action Contracting Strategy
RCRA	Resource Conservation and Recovery Act of 1976
RCRIS	Resource Conservation and Recovery Information System National Oversight Database
RD	Remedial Design
RD&D	Research, Development, and Demonstration
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIA	Regulatory Impact Analysis
RIS	RCRA Implementation Study
ROD	Record of Decision
RP	Responsible Party
RTC	Resolution Trust Corporation
RU	RCRA Regulated Unit
SACM	Superfund Accelerated Cleanup Model
SARA	Superfund Amendments and Reauthorization Act of 1986
SBA	Small Business Administration
SBIR	Small Business Innovative Research Program
SI	Site Inspection
SITE	Superfund Innovative Technology Evaluation Program
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethylene
TIO	Technology Innovation Office
TPS	Third Party Site [DOD]
TSD	Treatment, Storage, or Disposal
TSDF	Treatment, Storage, or Disposal Facility
TSDR	Treatment, Storage, Disposal, or Recycling Facility
UIC	Underground Injection Control
UMTRA	Uranium Mill Tailings Remedial Action Project
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxics and Hazardous Materials Agency
UST	Underground Storage Tank
VISITT	Vendor Information System on Innovative Treatment Technologies
VOC	Volatile Organic Compound
WPB	War Production Board